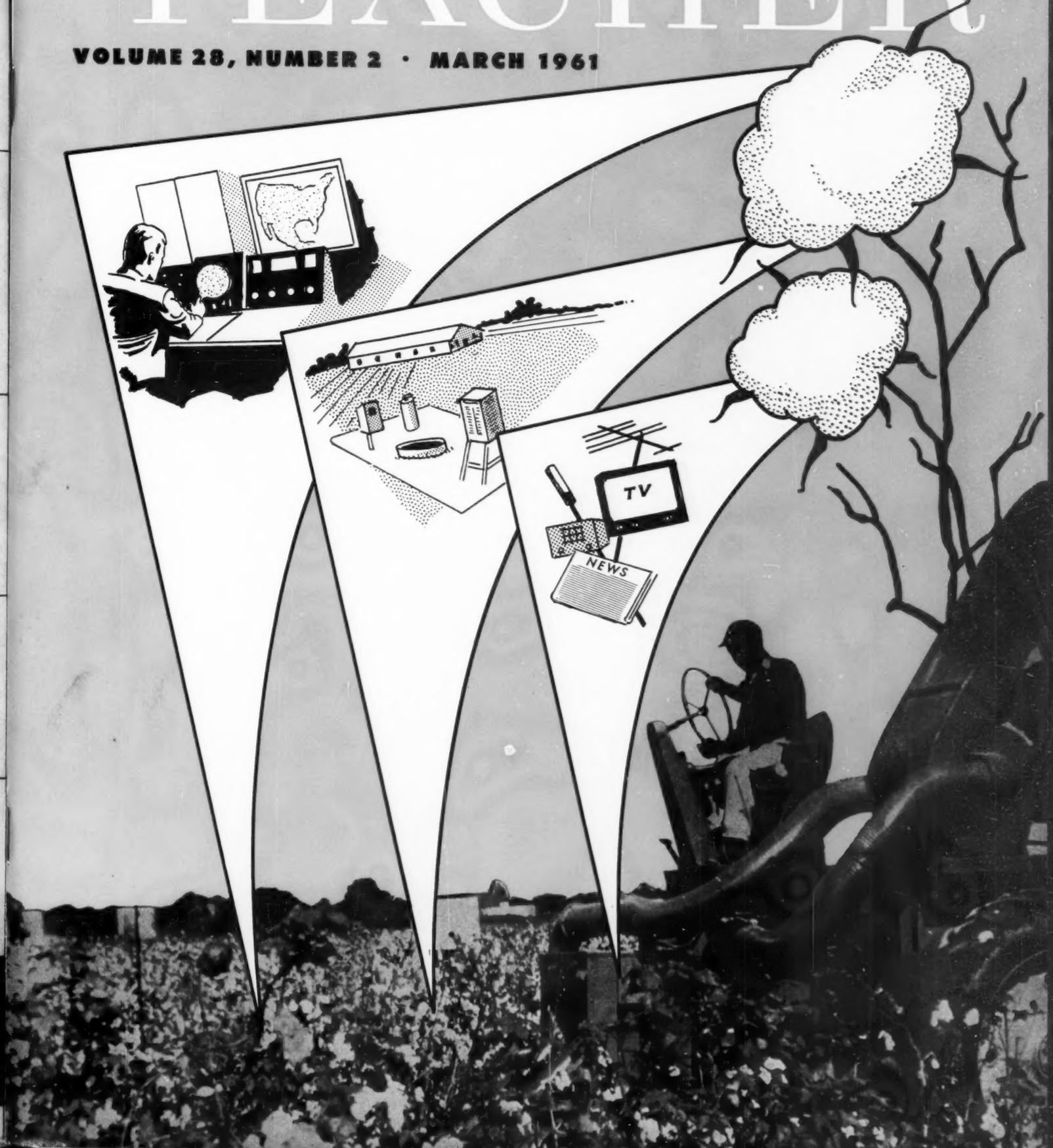
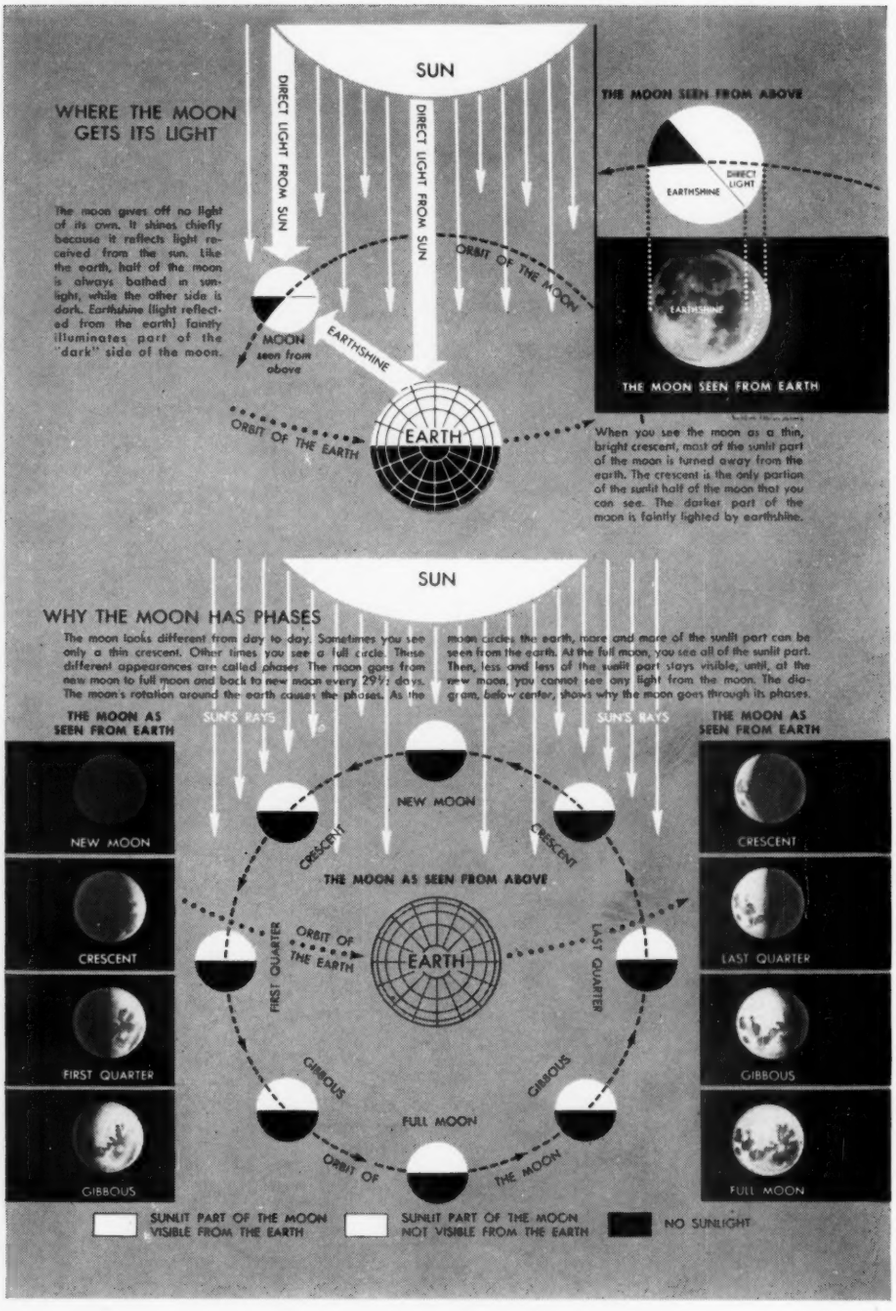
THE SCIENCE TEACHER

VOLUME 28, NUMBER 2 · MARCH 1961



This classroom-tested illustration from the Moon article appears in color in the 1961 World Book.


WHERE THE MOON GETS ITS LIGHT
The moon gives off no light of its own. It shines chiefly because it reflects light received from the sun. Like the earth, half of the moon is always bathed in sunlight, while the other side is dark. Earthshine (light reflected from the earth) faintly illuminates part of the "dark" side of the moon.
SUN
DIRECT LIGHT FROM SUN
DIRECT LIGHT FROM SUN
ORBIT OF THE MOON
MOON seen from above
EARTHSHINE
ORBIT OF THE EARTH
EARTH
THE MOON SEEN FROM ABOVE
EARTHSHINE
DIRECT LIGHT
EARTHSHINE
THE MOON SEEN FROM EARTH
When you see the moon as a thin, bright crescent, most of the sunlit part of the moon is turned away from the earth. The crescent is the only portion of the sunlit half of the moon that you can see. The darker part of the moon is faintly lighted by earthshine.
SUN
WHY THE MOON HAS PHASES
The moon looks different from day to day. Sometimes you see only a thin crescent. Other times you see a full circle. These different appearances are called phases. The moon goes from new moon to full moon and back to new moon every 29½ days. The moon's rotation around the earth causes the phases. As the moon circles the earth, more and more of the sunlit part can be seen from the earth. At the full moon, you see all of the sunlit part. Then, less and less of the sunlit part stays visible, until, at the new moon, you cannot see any light from the moon. The diagram, below center, shows why the moon goes through its phases.
THE MOON AS SEEN FROM EARTH
NEW MOON
CRESCENT
FIRST QUARTER
GIBBOUS
SUN'S RAYS
SUN'S RAYS
NEW MOON
CRESCENT
CRESCENT
THE MOON AS SEEN FROM ABOVE
FIRST QUARTER
ORBIT OF THE EARTH
EARTH
LAST QUARTER
GIBBOUS
GIBBOUS
FULL MOON
ORBIT OF THE MOON
THE MOON AS SEEN FROM EARTH
CRESCENT
LAST QUARTER
GIBBOUS
FULL MOON
SUNLIT PART OF THE MOON VISIBLE FROM THE EARTH
SUNLIT PART OF THE MOON NOT VISIBLE FROM THE EARTH
NO SUNLIGHT

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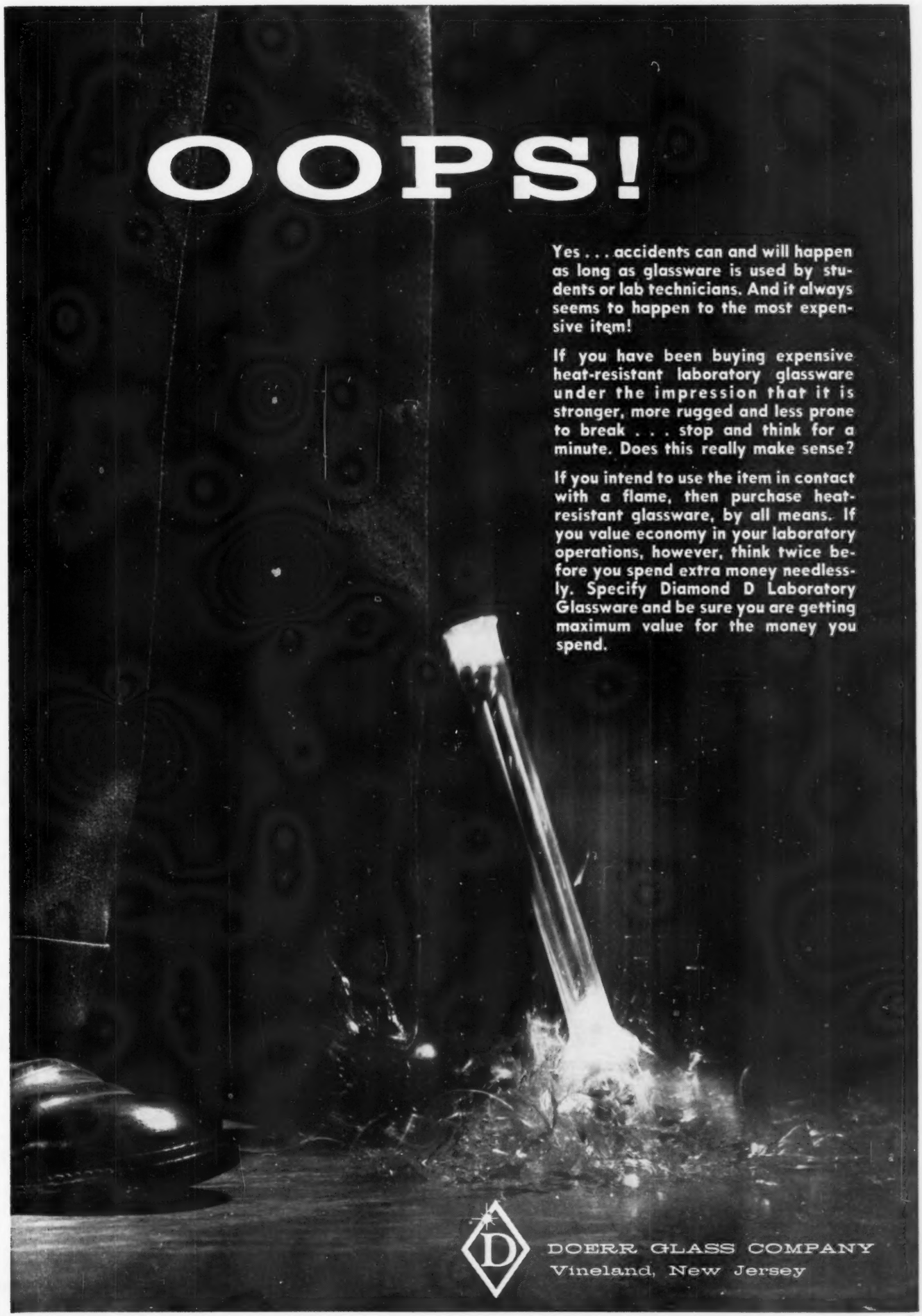
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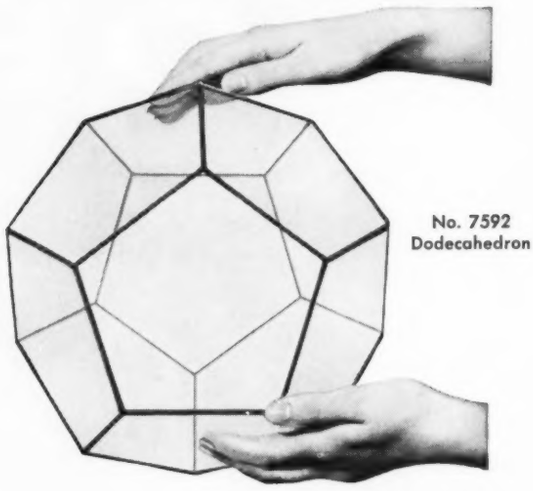

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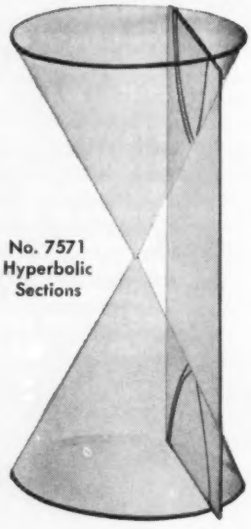
Dodecahedron



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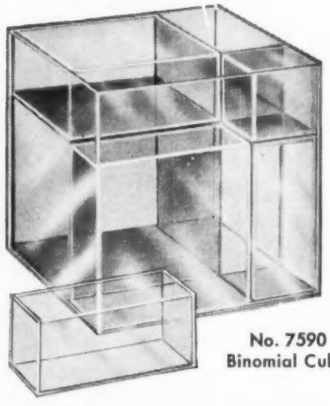
Hyperbolic
Sections



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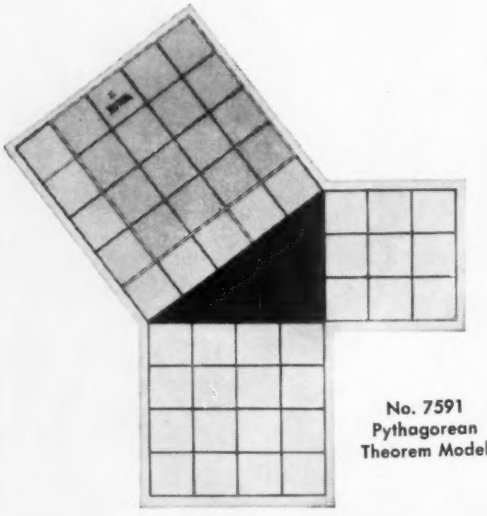
Binomial Cube



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The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

Journal of the National Science Teachers Association
Volume 28, Number 2 • March 1961

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NEA NOTES

EDITOR'S NOTE: From time to time, we will report events and data of interest from the other NEA units in this column. Additional information on the items reported may be obtained by writing the individual groups.

"Guidelines for Decision on Issues in Elementary Education" is the title of a filmstrip prepared for first showing at the Annual Meeting of the Department of Elementary School Principals in Atlantic City, March 19-22, 1961. It is based in part upon "Contemporary Issues in Elementary Education," a recent publication of the Educational Policies Commission, and is intended to serve as a guide in thinking through current educational issues. The film deals particularly with some of the "realities of society" and the "realities of learning."

"Guidelines for Decision" includes a filmstrip plus a recording and will be available from the Department of Elementary School Principals after March 22, for $8. Write directly to ESP, 1201 Sixteenth St., N. W., Washington 6, D. C.

Second Community Leadership Training Laboratory—A successful "first" will be repeated from July 2-14 when the National Training Laboratories of the National Education Association conduct the Second Community Leadership Training Laboratory at Bethel, Maine. The Laboratory, planned for the volunteer and the professional community worker, applies NTL's fourteen years of training experience and research to the human relations problems of community action. Last year, participants came from fourteen states across the country, many as members of local teams sent to develop greater skill and knowledge in achieving community teamwork and cooperation on important problems.

For further details, write H. Curtis Mial, Associate Director, National Training Laboratories, 1201 Sixteenth St., N. W., Washington 6, D. C.

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* Includes the *Elementary School Science Bulletin* published monthly from September through April of each year.

Legislators (politicians) do try to find out what the effects are of legislation that has been passed, and what the desires of those affected are in the design of future legislation. Take the National Defense Education Act of 1958 (NDEA), for example. This is a four-year program with two years to go. Yet congressional committees have already begun to review the Act and look forward to follow-up legislation. The Legislative Reference Service of the Library of Congress, in collecting information and materials for the committees, not unexpectedly turned to NSTA with a request that we determine how science teachers and supervisors "feel" about NDEA, particularly with respect to Title III. NSTA did comply and sent an opinionnaire to a sampling of 400 members of the Association, 100 state and local supervisors, 100 elementary teachers and principals, and 200 junior and senior high school classroom teachers. The total included two or more persons in all 50 states. Returns were as follows: 76 supervisors, 41 elementary, and 96 secondary for a total of 213 or 53.4 per cent. All but 8 of the returns could be tallied. Only 23 persons reported they were in schools, school systems, or states which did not participate in NDEA. Responses from participating teachers and supervisors to the opinionnaire items follow.

1. How Has NDEA Benefited the School Science Program:
   a. Through provision of supervisory personnel and services?

      There were 48.5 per cent who rated this effect as "great benefit" while 36.5 per cent described it as "moderate"; 15.5 per cent said there was "little or no benefit." Supervisors were considerably more enthusiastic on this point than were the elementary and secondary teachers.

   b. Through provision of equipment for laboratory and demonstration teaching?

      Supervisors, secondary teachers, and elementary teachers all rated this effect of NDEA overwhelmingly (71.4 per cent) as of "great benefit" in overcoming gaps, neglect, and deficiencies; 11.8 per cent thought the effect to be "moderate."

   c. Through the improvement of library facilities?

      Approximately 75 per cent of all respondents rated this effect as "great benefit" or "moderate." However, 37.8 per cent of the *secondary teachers* described it as "little or no benefit" or "don't know."

   d. Through stimulating reconsideration and strengthening of courses and curricula?

      If positive, this might be a "bonus" effect of NDEA since the Act does not provide direct support for such endeavors. Supervisors, secondary teachers, and elementary teachers were in high agreement that this effect was of "great benefit" (36.5 per cent) or "moderate" (41.4 per cent).

2. Do You Feel That There Are Negative Aspects of NDEA Such As:
   a. Overemphasis on science at expense of other curriculum areas?

      A resounding 81.8 per cent said "no" to this question. Only four respondents said "yes, definitely adverse."

   b. Excessive record keeping, reporting, or other "red tape"?

      All three categories of respondents were in high agreement that "no, requirements seem moderate and reasonable" (73.1 per cent). Of the remainder who felt "yes, far too much," those who objected to federal requirements, accounted for 9.4 per cent of the total, while another 13.5 per cent complained about their state requirements.

   c. Excessive control or regimentation?

      The responses to this inquiry show that 86.4 per cent of all respondents felt that "no, individual freedom and responsibilities are recognized and satisfactorily provided for."

   d. Overemphasis on purchase and use of audio-visual materials?

      This question was asked because some claims have been made that audio-visual materials and methods may be used to excess at expense of firsthand laboratory work in science. The respondents (90.0 per cent) voted "no, distribution of funds reasonably balanced."

   e. Inequities among schools or grade levels?

      Again, all three categories of respondents were in high agreement in believing "no, distribution of funds reasonably satisfactory" (68.8 per cent); only a scattering of replies indicated neglect of one level or another—elementary, junior high, or senior high—or "yes, richer districts benefited disproportionately."

3. As a Classroom Teacher, How Have You Benefited from NDEA:
   a. Acquisition of equipment and teaching aids?

      Elementary and secondary teachers alike agreed that the impact was "very great" (40.7 per cent) or "moderate" (52.4 per cent). Only 6 respondents said they had received "no benefit."

   b. In receiving supervisory or consultative personnel and assistance?

      Only 20.1 per cent reported this as a benefit in "great" or "moderate" degree; 80 per cent indicated "no" provision of such help at local or system level.

   c. In being provided time to do course revisions, curriculum planning, etc.?

      It was felt that this might possibly be another "bonus effect" of NDEA. Apparently not, since 82.9 per cent of the teachers reported "no" to this item.

   d. In being provided with an improved daily or weekly teaching load?

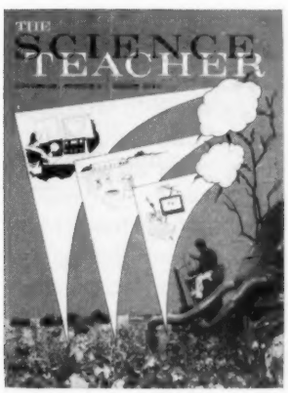
      Again, a hoped-for fringe benefit apparently did not result, since 81.4 per cent of the teachers reported "no" to this question.

4. What Do You Recommend to the 87th Congress?

   The returns on this question showed better than 90 per cent agreement among supervisors, secondary teachers, and elementary teachers. Considering all replies, 91.3 per cent voted for continuing federal support for schools in one of three forms:
   a. Some 32.1 per cent said "continue NDEA essentially as is."
   b. Another 38.2 per cent said "expand NDEA to include such fields as English and social studies."
   c. And 21.9 per cent said "drop NDEA in favor of a general school support bill."

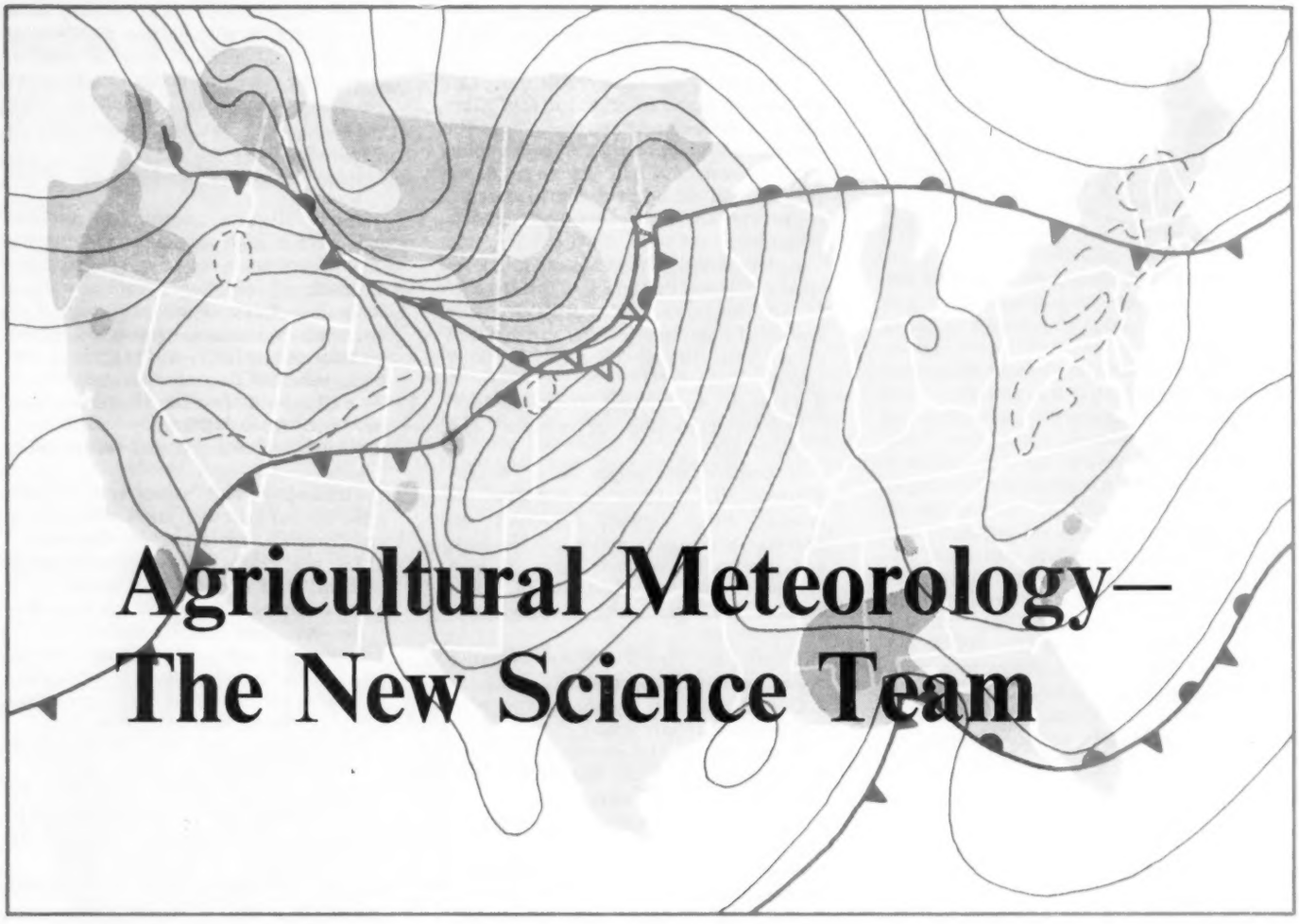
The above report has been submitted to the Legislative Reference Service of the Library of Congress and to the NSTA Board of Directors. It seems only proper to report also to the membership and to science teachers at large via *TST*. All who are concerned with NDEA and other federal legislation for schools should, of course, feel free—no, should feel obligated—to convey their concern and recommendations, (pro or con), to their Senators and to their Representatives in the House.

Robert H. Carleton



THIS MONTH'S COVER . . .

The agricultural-meteorology team—Weathermen, agricultural scientists, broadcasters, newsmen, and telecasters are all links in the flow of tailored weather information to the farmer. This science team, operating in the heart of Mississippi cotton country, delivers timely forecasts via the news outlets to aid the farmers' day-to-day operations. Behind this continuous service (described in the lead article), the agrometeorological research team probes the unanswered questions of weather's part in agricultural production. (Cover by courtesy of the U. S. Weather Bureau; artist, Marshall Kathan.)



Agricultural Meteorology—The New Science Team

By DONALD P. SPRINGER

Agricultural Meteorologist, U. S. Department of Commerce, Weather Bureau, Washington, D. C.

THE environment of plants, animals, and man, located at the boundary of the vast ocean of atmosphere and the great mass of the earth, provides a laboratory where many independent variables are involved and few of them can be controlled. Because of these variables and their many individual fluctuations, meteorology and agriculture have gone through a long process of empirical development before any related physical principles began to unfold to enable much progress.

Today, meteorology has progressed to the point where fluid dynamics and the equations of motion derived therefrom are utilized operationally in forecasting broad-scale atmospheric patterns. This science stands at the threshold of revolutionary new developments as satellites show promise of relaying from the edge of our weather-producing atmosphere, information on the planet's heat balance and other global factors.

Agriculture, also, has developed to the point where, under uniform weather conditions, the variability from plant to plant of a given variety has been largely eliminated. The plant's nutritional requirements are defined, the soil environment of the plant can be modified, and diseases and insect pests can be controlled. Agricultural scientists have developed the cyclotron or controlled climate chamber as a tool in assessing all of agriculture's variables with the exception of weather. Through these developments the agronomist can state, "The DK-600 Hybrid corn, planted at x-pounds to the acre on Bolden Sandy Loam, with 350 pounds of 12-6-4 boron supplemented fertilizer per acre, and supplemental irrigation to maintain the soil at 75 per cent or more of field capacity with appropriate applications of insecticide, can be expected to produce 125 bushels per acre, *if weather conditions are favorable.*"

The future may bring an era of agricultural development in which weather conditions can be controlled in the plant zone. Even today, with irrigation systems, an adequate moisture supply can be guaranteed in some areas. There is still no control, however, for excessive moisture, nor for sunshine, temperature, or wind.

As the margin between income and cost of production in agriculture narrows, the farmer searches for methods of greater production efficiency. Most

of the facets of agricultural technology that experienced rapid development during the last two decades have nearly matured; but the growth period of the application of meteorology to agriculture is just "beginning." In this effort a new and important science team is fast developing to bring to light agriculture-weather relationships. Practical applications of weather science to early plant growth and control were utilized by man even in his most primitive life. Current research efforts have developed from man's early simple experiments.

In the last two years, some of the vast potential of the science of agricultural meteorology has shown itself through a pilot project in agricultural weather service established in October 1958 in the Mississippi Delta Area, the rich alluvial land flanking the east bank of "Old Man River" from Memphis to Vicksburg. This is the traditional plantation country where cotton is *king*. Here, the centuries old production practices have given way essentially to mechanization.

In the heart of the Delta, a group of agricultural scientists at the Delta Branch of the Mississippi Agricultural Experiment Station, the U. S. Department of Agriculture Cotton Ginning Laboratory, and private companies such as the Delta and Pine Land Company, have revolutionized the production of cotton and other crops in the climate of the humid Southeast. Insect and disease resistant—but not immune—varieties of cotton have been developed; insecticides, fungicides, and their application are studied; and the mechanical cotton picker has been engineered. To this agricultural science team of plant pathologists, physiologists, agronomists, entomologists, botanists, agricultural engineers, and agricultural economists has been added an Advisory Agricultural Meteorologist. His purpose—to help farmers utilize weather as an ally rather than an adversary in crop raising.

From planting through harvest and processing, cotton is one of the most weather-sensitive of crops. When soil temperatures fall below 60° F or if the soil is water saturated, seed will rot in the ground, and vast acreages must be replanted. As the crop develops, the year's first generation of destructive insects hatches, and in this climate several more generations follow before

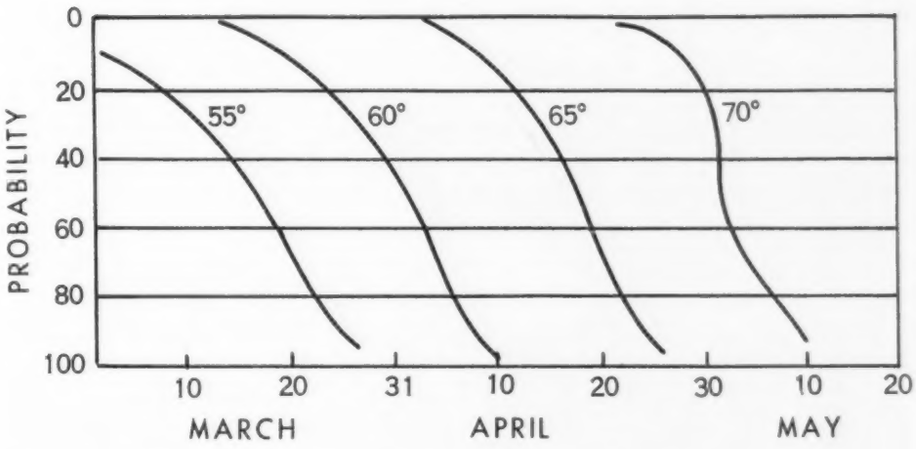
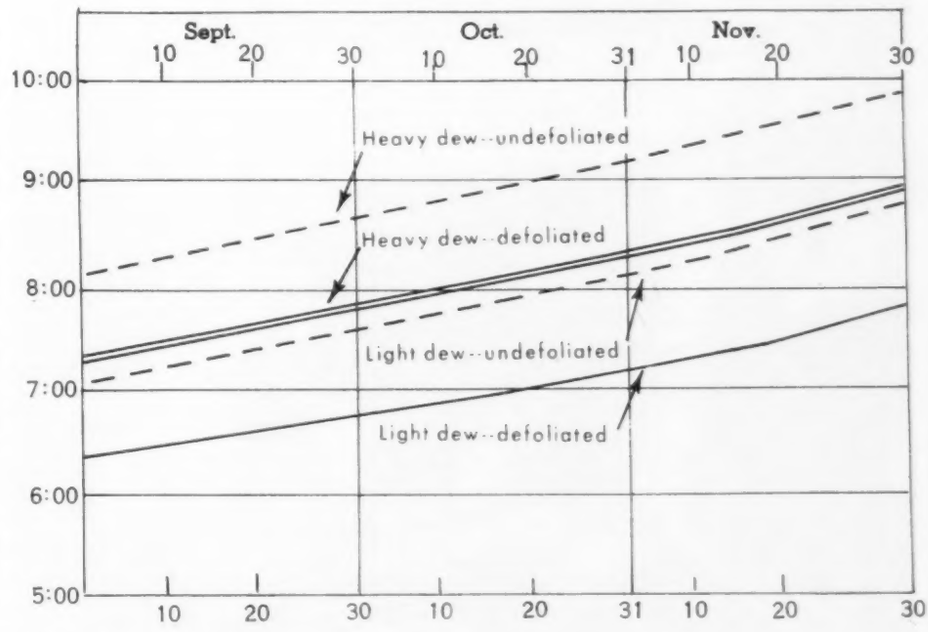


Figure 1. Probability that the average soil temperature will reach certain levels during the spring.

cold weather suspends insect activity. Summer and thunder showers which occur at intervals of only a few days reinforce the moisture of already hot, humid air to provide an ideal environment for fungus diseases. As the crop matures, the plants must be defoliated for the mechanical picking machines. If frost comes early enough, Nature removes the plant foliage; if not, chemicals must be applied to do the job.

The science and practice of agricultural meteorology are applied in nearly all operational planning and cultural practices throughout the crop season. The weather-agriculture team established has made these applications possible through meeting the four basic

Figure 2. DAILY GUIDE FOR BEGINNING MECHANICAL COTTON PICKING*
(Applicable in Mississippi Delta Area)



*Applies to clear weather--

If rain in previous 24 hours, use heavy dewlines regardless of dew intensity.

If strong winds are blowing, subtract approximately 30 minutes.

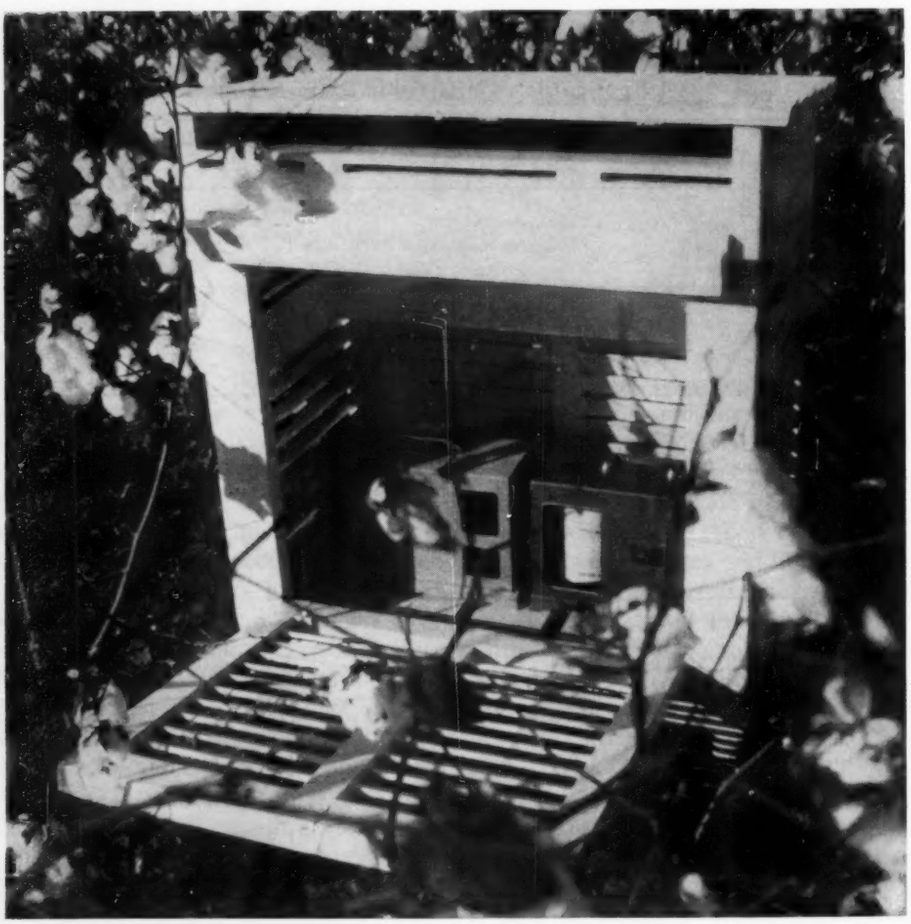
Under persisent cloudy skies, add 30 minutes or more.

If it rains, DO NOT PICK.

NATIONAL COTTON COUNCIL, MEMPHIS, TENN.

Weather forecasts are important to aerial application of agricultural chemicals.

Measuring and recording temperature and humidity in ripe cotton.



needs of modern agriculture for weather service. These requirements are:

1. Frequent issuance of weather forecasts geared to current operations.
2. Communications to make this information immediately available throughout the service area.
3. Joint research and liaison between meteorologists and agriculturists.
4. Education to show agricultural interests how to let weather and weather information work for them.

In the Mississippi Delta, these requirements were met by providing *Specialized Farm Weather Forecasts* prepared by experienced agricultural weather forecasters and issued at least three times daily. These forecasts include the expected amount and per cent of areal coverage of precipitation, the amount of cloudiness, temperature extremes, wind speed and direction, dew intensity and duration, and other meteorological factors of importance to agriculture.

Weather Teletypewriter Service to make forecasts and other agricultural weather advisories immediately available to everyone in the service area. This service is equally available to all radio and TV stations and other mass-distribution outlets in the service area.

Research on agriculture-weather relationships and their application to farming.

Extension Advisory Service by county agents and through the issuance of Daily Farm Weather Summaries which interpret weather conditions in terms of their influence on current farming operations.

The weather-agriculture research team in the Mississippi Delta Area has produced a number of valuable methods for use by farmers in increasing the efficiency and quality of production. The final result in using one method included recommendations on the date for spring planting of cotton. Agricultural scientists have determined the soil temperatures required for germination and growth of cotton seeds; experiments show that 10 per cent of the seeds planted emerge at a soil temperature of 60° F, 75 per cent at 65° F, and 93 per cent at 75° F. Field studies show that soil temperature of 65° F is a practical level for planting. Studies of the climate of the Delta wherein long-term records of air temperature were compared with relatively short records of soil temperature led to an analysis

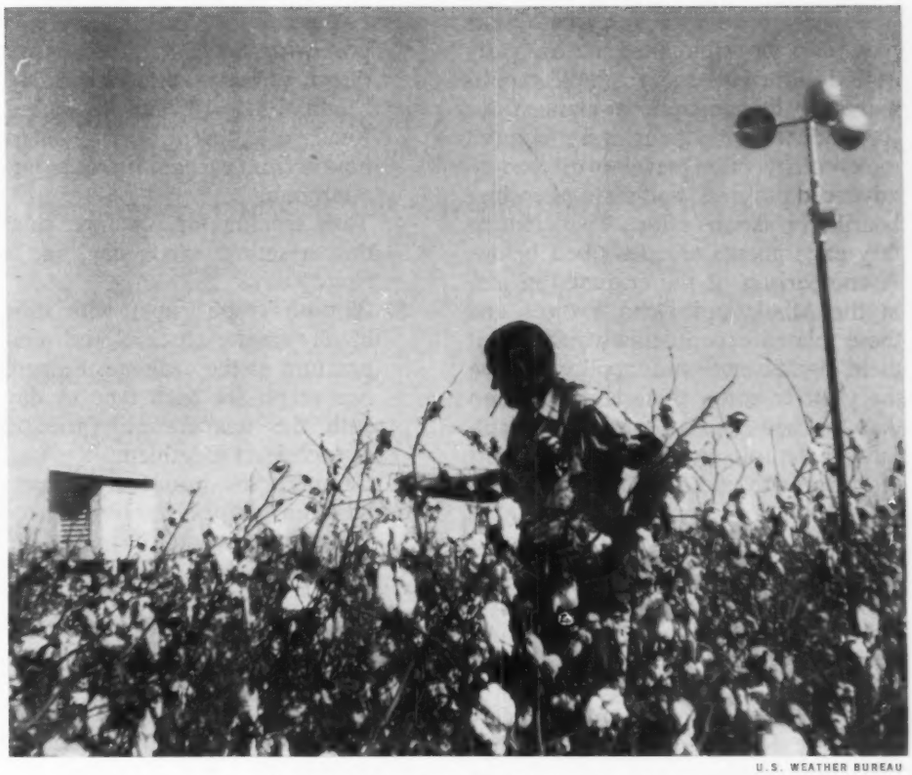
of the probability of soil temperature in the planting zone reaching certain levels during the spring months. Figure 1 shows this relationship.[1]

Through this analysis, the farmer knows that the soil temperature will be 65° or higher by about April 22 in eight years out of every ten. This probability, coupled with the long-range (30-day) weather outlook regularly prepared by the Weather Bureau, provides the farmer with an estimate of his chances of obtaining a good stand of cotton at the various possible planting dates which are determined.

The usefulness of this combination of climatological analysis and long-range weather forecasting was demonstrated in the 1959 crop season when an outlook for unusually cool weather for the period from mid-March to mid-April led to a recommendation that farmers delay cotton planting until late April or early May. Farmers in the area estimated that nearly one million dollars in replanting costs were saved through this recommendation.

In another research project, stimulated by intense interest in cotton-quality improvement, field studies were made of the hour-to-hour variation of relative humidity in defoliated and undefoliated cotton fields at harvest time. A comparison of these studies with previous measurements of the moisture of the seed cotton at ginning and of the relationship between this moisture content and relative humidity in the field resulted in the development of "A Daily Guide for Beginning Mechanical Picking," reproduced as Figure 2.[2] This guide shows farmers the earliest time of day at which mechanical cotton pickers may be used with assurance of sufficiently low cotton-moisture content to protect cotton quality.

Many other studies are being conducted by the weather-agriculture research team. The research is showing more and more conclusively that weather's influences on agricultural production go far beyond the obvious effects of flood, drought, freezing, and searing heat. The surface has been barely scratched in uncovering and understanding the more subtle influences that are so important to efficient production of our nation's food and fiber.



U.S. WEATHER BUREAU

Measuring the microclimate of the cotton field.

The most immediate results of the agricultural weather service in the Delta accrue from the daily farm weather forecast program. These forecasts, furnished for use as a factor in day-to-day planning of farming operations, are a highly perishable product. They utilize reports from weather-surveillance radar that tracks showers, thunderstorms, and severe weather across the area. The communications system utilizing teletypewriter circuits that connect the weather forecasting offices to radio and television stations throughout the area makes these forecasts immediately available to every farmer.

The ideal weather service for the farmer would be one in which a completely accurate forecast of day-to-day weather could be given for the entire crop season. However, the present state of the art and science of meteorology permits only 80 to 85 per cent accuracy for a twenty-four to thirty-six hour period and limits even broad statements of general trends in weather to a maximum useful period of about thirty days. Because of these limitations, specialized weather forecasts for agriculture are tending toward expression in terms of probability. When the chances of showers are expressed in terms of the percentage of the forecast area that can be expected to receive rain, the farmer can estimate the risk involved in performing an operation that will cost him extra money if the showers fall on his farm.

The Mississippi Delta Project represents a new furrow in the field of agricultural weather service which has lain fallow for most of the last thirty years. The project's byword is service, a service that makes up-to-the-minute operational weather forecasts available to every Delta farmer. The forecasting service is supported by modern tools of meteorology including weather-surveillance radar and the electronic digital computer. The basic forecasts are service-oriented through the weather-agriculture team's operational interpretation of available meteorological information. Climatological information is geared to service applications by presenting it in terms of probability rather than the shopworn averages, means, and normals. Crop-weather research results in service through the educational program directed toward the farm operator.

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[1] J. A. Riley. "Climate of the Delta Area of Mississippi." Bulletin 505. Mississippi State College Agricultural Experiment Station, State College, Mississippi. September 1960.

[2] J. A. Riley and E. B. Williamson. "Relative Humidity in Cotton Fields at Harvest Time." Bulletin 581. Mississippi State College, State College, Mississippi. July 1959.

Service to advance research results may also be stimulated at an early period in the classroom. Simple experiments or demonstrations planned for the student in the areas of agricultural meteorology often develop or lead to advanced progress, and serve as springboards for serious effort. Two elementary experiments are described below. A comparison of the current research in the Mississippi Delta Project and these related experiments would reveal their significance and application. In the years to come, there is no question that the new science team of agricultural meteorology will be a vital part of our growth and development.

Experiments in Agricultural Meteorology

I. Hay Curing Weather—Its Influence on Quality.

Procedure

1. Cut a sample of tall grass (preferably clover, alfalfa, or another leafy legume) and divide it into two equal portions.
2. Place both samples in a sunny spot for three or four hours.
3. Remove one sample, spray it with water (equivalent to a ½-inch rain shower), and remove it from sunshine for an hour or two.
4. On the following day, again place both samples in an exposed sunny location.
5. Compare both samples when the one which has not been "rained on" is cured, *i.e.*, dry but not brittle with a good green color.

Observation

The difference in quality in the two samples of hay will be apparent to the eye, to the touch, and, if facilities for chemical analysis are available, marked differences in protein content and other important nutritional factors can be measured. It can be noted that the "rained on" sample is subject to shattering of leaves from the stem, that it is brittle, pithy, and darkened in color (an indication of vitamin loss).

II. Observation of Micrometeorological Temperature Variations.

Procedure

1. Obtain three mercury-in-glass thermometers calibrated for outdoor use.
2. Expose the thermometers on a post with shield to protect from direct sun rays at the over-sod heights of 4, 18, and 48 inches.
3. Read all three thermometers hourly from early morning to late afternoon.
4. Take readings on a sunny, calm day, a sunny, windy day, and a cloudy day.
5. Plot on graph paper with time of day as the abscissa and temperature as the ordinate. Prepare one graph for each type of day with the temperature variation at each level identified.
6. Compare the variation of temperature with height on each of the various types of days.

Observation

A relatively simple study of this nature shows the tremendous variations in climate in the plant environment. It also indicates the role of the surface of the earth in the absorption of heat and the subsequent warming of the atmosphere. Secondarily, it gives a hint as to the role of wind in distributing the heat absorbed at the surface and shows the uniformity of temperature under cloudy skies when the heat from insolation is filtered out by cloud cover.

The Weather Bureau hopes to be able to extend services as described to all of the nation's intensive agricultural production areas. Agricultural meteorologists and agricultural scientists are looking forward to a double-barreled program of weather service for agriculture in the future. First, to present to farmers and the general public timely weather advices tailored to their operational needs. Second, to continue and to expand research into the influences of weather and climate on agricultural production. Both phases of this program are in their infancy compared to other phases of agricultural technology, and close cooperation between the sciences of agriculture and meteorology will be required to bring them to their full stature in the progress of science.

Field studies show weather's influence on quality of machine harvested cotton.

U. S. WEATHER BUREAU.

TEACHING OF ATOMIC STRUCTURE

Report of the Course Given in the High Schools of the Soviet Union

By GEORGE SIEMIENCOW

Instructor, Department of Chemistry, Lafayette College, Easton, Pennsylvania

NOTE: Presented at the Third Delaware Valley Regional Meeting of the American Chemical Society in Philadelphia, Pennsylvania, February 25, 1960. Permission for publication in TST has been granted by the American Chemical Society.

WITH the advance of science in all countries and particularly the emphasis placed on curriculum development in Soviet Secondary Schools, it may be of interest to describe one of the important science units introduced in the Soviet curricula, namely, "Atomic Structure."

In an earlier study,[1] the teaching of chemistry in Soviet Secondary Schools was published in 1959. Both articles are based on my studies of Soviet textbooks, syllabi, and methodic literature. The approach has been to gather material from the historical and present status of the teaching of these units.

First attempts to introduce the atomic structure into high school chemistry were made in the mid-twenties. Some textbooks introduced the atomic structure at the end of the course together with the periodic system, but did not use the atomic structure to explain the properties of the elements.

In the year 1932, the syllabus and the standard textbook placed the atomic structure together again with the periodic system after the discussion of nonmetals was finished. Again, no attempt was made to use the atomic structure to explain the properties of elements.

In the syllabus for the year 1948-49, atomic structure was introduced for the first time in the second year of high school chemistry study. Four years are the total number devoted to chemistry with a more detailed discussion of atomic structure given in the last year.

This solution, together with the attempts of some teachers to introduce atomic structure in the first year of chemistry study, met with strong criticism and was abandoned for the time being. In 1958, however, the earlier introduction of atomic structure was strongly defended by Kiryushkin,[2] author of the standard textbook for grade 7, in the second edition of his teacher's manual for methods of teaching chemistry in high school.

According to the syllabus worked out by the Academy of Pedagogical Science of the Russian Soviet Federated Socialist Republic (RSFSR) in the early fifties, the atomic structure was placed after the discussion of the periodic system in the beginning of the third year of chemistry study. With some changes, this syllabus was used until the recent reorganization in Soviet education in all schools, and to a great extent it is still in use. In this syllabus, atomic structure is preceded by a discussion of the fundamental concepts and laws of chemistry, atomic theory, alkali metals, halogens, oxygen, and sulfur. It is followed by the discussion of nitrogen and phosphorus, carbon and silicon, and metals. The properties of all of the elements that follow the unit "Atomic Structure" should be studied according to the syllabus and are discussed in the standard textbook on the basis of their atomic structure.

T. M. Drizovskaya[3] in her work, *The Study of the Problems of the Atomic Structure in the High School Course of Chemistry*, formulates the purposes of this unit: . . . "to acquaint the students with the structure of the atoms of the first three periods of the periodic system, to give an idea about the diversity of forms of matter, and their qualitative distinction and their unity, at the same time." It further explains to the students the formation of compounds with a covalent and electrovalent (ionic) bonding and the nature of valence. The student should also master the concepts of "element" and "isotope" and understand the following aspects of the periodic law in the light of the atomic structure: (1) The physical significance of the periodic law, (2) The reasons for the similarity of elements of one family, (3) The reasons for the change of the properties of the elements in one period, and (4) Physical significance of the atomic number of the elements and the order of the distribution of the elements in the periodic system. As a result of the study of this unit, the student should see the part played by Russian scientists in the shaping of the theory of atomic structure, and also the meaning of this theory for the development of the science and the dialectical-materialistic world outlook.

After studying this unit, the student should be able (1) to draw electronic diagrams for the elements and ions of the three short periods, and on the

[1] George Siemiencow. "Teaching of Chemistry in Soviet Secondary Schools." *Proceedings of the Pennsylvania Academy of Science*, 33:106. 1959.

[2] D. M. Kiryushkin. *Metodika prepodavaniya khimii v sprednei shkole.* (Methods of Teaching Chemistry in High School.) Moscow. 1958.

[3] T. M. Drizovskaya. *Izucheniye voprosov stroyeniya atomov v shkolnom kurse khimii.* (The Study of Problems of Atomic Structure in the High School Course of Chemistry.) Moscow. 1958.

EDITOR'S NOTE: The author was born in Kiev, Russia, attended secondary school there and received the degree of Chemist (MS Degree equivalent) from the Public University of Kiev. He taught at a secondary school and engineering institute in Russia. Although completing his work as a degree candidate for a doctoral in the chemical sciences (PhD equivalent), it was not conferred due to the interference of World War II. His teaching experience began in a displaced person's camp (six years) until 1951 when he came to America. He joined the staff at Lafayette College in 1953.

basis of the atomic structure to make conclusions about the properties of the elements, (2) to draw diagrams of compounds with covalent and ionic bonding and write equations of simple oxidation-reduction reactions in electron-ionic form, and (3) to find the similarity and the difference in structure and properties of elements of the same family and of the same period, and in connection with this the likeness and difference in forms and properties of their compounds.

The unit "Atomic Structure" in the standard textbook[4] is divided into the following subunits: Electrons—constituent parts of atoms, Radioactivity, Nucleus—a constituent part of the atoms, Composition of atomic nuclei, Isotopes, The atomic structure of the elements in the short periods, Combination of atoms into molecules, and Valence of elements and atomic structure.

From nine to eleven hours are assigned to the unit. Drizovskaya[5] proposes the following distribution of material:

Lesson 1. Short information from the history of the development of the atomic theory. Discovery of the electrons.
Lesson 2. Radioactivity.
Lesson 3. The presence of a positively charged nucleus in the atom. The planetary model of the atom.
Lesson 4. Electron levels of the atom.
Lesson 5. The structure of the nucleus of the atom. Isotopes.
Lesson 6. Summary.
Lessons 7-8. Chemical bond. Valence.
Lessons 9-10. The periodic law and the periodic system in light of the theory of atomic structure.
Lesson 11. Summary of all the material covered in the unit, "Atomic Structure."

D. M. Kiryushkin[6] proposes a different distribution of material:

Lesson 1. First acquaintance wtih the phenomenon of radioactivity.
Lesson 2. Atomic structure.
Lesson 3. The structure diagrams of elements of the first three periods of the periodic system.
Lesson 4. Chemical bonding and valence.
Lesson 5. Explanation of chemical reactions from the point of view of electronic theory.
Lessons 6-7. Radioactive changes and the composition of the atomic nuclei.
Lesson 8. The periodic system in the light of the atomic structure.
Lessons 9-10. Review and examination.

The discussion of the atomic structure in the standard textbook is on a high level, certainly not lower than that presented in American high school chemistry texts. Two strange mistakes or oversimplifications should be noted. After explaining very clearly the formation of sodium and chloride ions, the author claims that these ions are attracted one to the other to form a *molecule* of NaCl. He also claims that the valence of an element is equal to the amount of electron pairs binding its atom to other atoms.

T. M. Drizovskaya[7] in her work gives detailed outlines for all lessons. I have translated one of them in my above-mentioned work under footnote reference No. 1.

She also discusses the different methodic approaches to the teaching of atomic structure at length, and subdivides these approaches into three classes: informationally dogmatic, historically logical, and informational with elements of proof.

The "informationally-dogmatic" method consists of the dogmatic exposition of basic concepts of the theory of atomic structure without proof, without any information about the methods by which these theories were discovered, and without any demonstrations.

The "historically-logical" method consists of the exposition of the basic concepts of the theory of atomic structure with proof and in its historically logical consequence. The most important apparatus are demonstrated.

In the "informational method" the basic concepts are first exposed with elements of proof, and then the student is acquainted with the methods by which they were discovered. Different kinds of apparatus are demonstrated in action.

Experimental lessons performed in several Moscow schools proved that the results are better when the two last methods are used.

As a result of analysis of examinations and individual talks with students, the author finds topics that are particularly difficult for students. They are: proof of existence of electrons, proof of existence of the atomic nucleus, the part played by Russian and Soviet scientists in the development of the atomic structure, the periodicity of the properties of the elements, the essence of the covalent bond, relationship between the atomic structure of the elements of one subgroup and their properties, and the difference between the structure and the properties of an atom and an ion of the same element.

The following statement from the standard textbook[8] is interesting as it shows the intensity of the fight of the Soviet rulers against religion: "By shaping the theory of atomic structure, science has proved again that even the most complicated phenomenon of nature can be cognized. In this way again and again science refutes the assertion of religion that man cannot penetrate in the essence of phenomenon of nature and cognize them. Science is incompatible with religion and opposed to it."

On the basis of additional material that was published or became available after the presentation of the author's initial paper, conclusions can be drawn about the place of the unit "Atomic Structure" in the chemistry syllabus of the Soviet school after the recent reorganization.

The syllabus of the eight-year school[9] does not contain anything indicating that the atom consists of smaller particles. In the syllabus of the Secondary School with Production Training, three years will be added to the eight compulsory years for some students. "Atomic structure" will constitute, together with the periodic system, the fifth unit of the first of three years of chemistry study.

In conclusion, here is a translation of the Unit: "Periodic law and the periodic system of chemical elements of D. I. Mendeleev. Atomic Structure." From the syllabus for the school year 1958-1959.[10]

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[4] Yu. V. Khodakov, L. A. Tsvetkov, S. G. Shapovalenko, D. A. Epshtein. *Khimiya. Uchebnik dla 8-10 klassov srednei shkoly.* (Chemistry. Textbook for 8-10 Classes of the Middle School.) Moscow. 1960.

[5] *Loc. cit.*

[6] *Loc. cit.*

[7] *Loc. cit.*

[8] Y. V. Khodakov et al, *loc. cit.*

[9] *Programma po khimii vos'miletnei shkoly.* (Chemistry Syllabus of the Eight-Year School.) *Khimiya v Shkole* (Chemistry in School.) May-June, 1960. p. 10-18.

[10] Glavnoye Upravelniye Shkol Ministerstva Prosveshcheniya RSFSR. (Chief Office of Schools of the Ministry of Education of RSFSR.) *Programmy Sredney Shkoly. Khimia.* (Syllabi of Secondary Schools. Chemistry.) Gosudarstvennoye uchebno pedagogicheskoye izdatel'stvo ministerstva prosveshcheniya. Russian Soviet Federated Socialist Republic. Moscow. 1958.

"Periodic law and the periodic system of chemical elements of D. I. Mendeleev. Short and long periods. Groups and subgroups. Prediction of new elements by D. I. Mendeleev. Atomic Structure. Short information about radioactivity. Atomic numbers of elements and the charges of the nuclei. Short information about the composition of the atomic nucleus: protons and neutrons. Isotopes. Electronic levels of the atoms of the I-III periods. Formation of compounds in the light of the ideas about atomic structure. Ionic and atomic bonding. Dissociation of acids, salts, and bases in water. Reaction of acids, salts, and bases in solutions.

"Periodic law and the periodic system of the elements in the light of the data about atomic structure. Importance of the works of D. I. Mendeleev for the development of chemistry.

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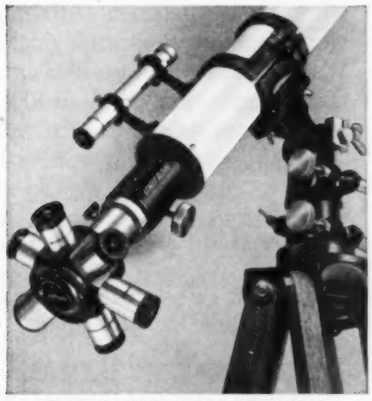

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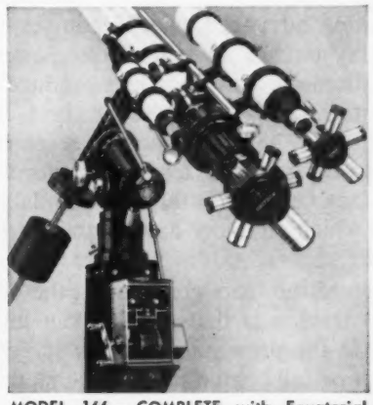

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INVESTIGATIONS OF LIVER AND KIDNEY

Design of a Dual Apparatus for Research Study

By **FREDERICK R. AVIS**

Chairman, Science Department

and **ANNA PLISCZ**

Research Assistant, Saint Mark's School, Southborough, Massachusetts

IN the spring of 1959, the National Cancer Institute of the National Institutes of Health awarded the author a three-year research grant for an investigation of the effects of anticancer drugs on perfused bovine blood, the kidney, and the liver.[1] The problem resolved itself into three parts: (1) to design an apparatus for the simultaneous perfusion of the liver, as well as the kidney; (2) to establish norms for the blood, tissues, and urine for controlled perfusions without drugs; and (3) to proceed with an investigation of drug action. The accompanying article reports on the first two parts of the work, and the third aspect is now in operation.

The apparatus described herein is purely a research instrument and costs approximately $1500 to duplicate. For teachers and students who might like to work with a simpler perfusion apparatus, detailed information on one costing about one-tenth of this amount is described in the author's book.[2]

When the grant was awarded, the National Cancer Institute was not only interested in the scientific aspect, but also in the ramifications and possible trends such projects might have in the field of science education at the secondary school level. Some of these are briefly presented below.

Everyone is aware of the shortage of scientists in our country. Since many teachers at the secondary school level have the training and ability to carry out research programs, they may prove to be a significantly large, untapped source of scientists.

As one who has been concerned with the hiring of high school science teachers over a period of twenty-five years, the author has often been disappointed in the loss of outstanding teachers to colleges and research institutions. Although the teachers have been inspired and have enjoyed teaching secondary school students, the urge and opportunity to do research became more of an incentive to follow. Apparently, this trend is developing, since programs such as summer institutes provide opportunities for advanced studies and thereby expose the teacher to advanced laboratory work with its exciting problems related to research. This is bound to lure people who possess active, imaginative, scientific minds over to the pursuit of pure research. Let there be no misunderstanding in the reader's mind as to the attitude of the author in regard to the secondary school teacher taking advanced science courses in this day and age. It is an absolute must. The situation, however, does produce a dilemma which perhaps can best be solved by the awarding of research grants to qualified teachers in order that they can satisfy this commendable need which so many have ingrained in them.

One of the fears confronting the devoted teacher is that he may slip into a rut in the presentation of his subject matter or fall behind in his understanding of new developments, and the process of mental necrosis will thereby begin its gradual development. Research may be described as a preventive medicine because it is bound through discipline and challenge to keep the mind active, alert, and imaginative.

Turning now from the teacher to the students, we find that research undoubtedly has additional, far-reaching effects on their work. To have a research project carried out in their own laboratory is exciting and arouses tremendous student interest. Not only are the students who are actually enrolled in science courses following the program closely, but on "perfusion days" when the apparatus described herein is in operation, there is a continual flow of all members of the student body into the laboratory. At Saint Mark's we have six forms with an age span from twelve to nineteen years, and from the youngest to the oldest the program has developed enthusiasm and interest in science. Just how much motivation toward careers in science is developed only time can determine, but we do expect to carry out follow-up studies on these students to ascertain possible effects of the program on career choices.

A definite practical advantage for the students is that the apparatus used in the research program for the analysis of blood, tissue, and urine can also be adapted to work in other courses. The equipment has made possible the design of more meaningful, advanced laboratory experiments. Examples are work involving the histological unit, the Warburg apparatus for measurement of tissue respiration, the Van Slyke apparatus for analysis of oxygen and carbon

TABLE I. Summary of the average loss of red and white cells during the six-hour perfusion.

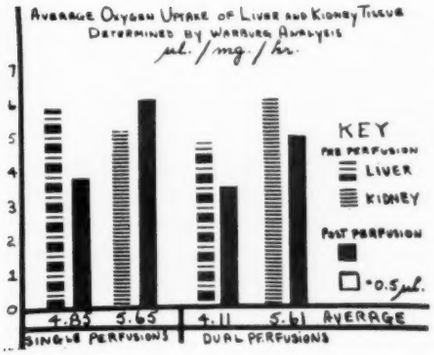
AVERAGE LOSS OF RBC AND WBC DURING 6-HR PERFUSIONS

	CONTROL		KIDNEY		LIVER		DUAL	
	RBC	WBC	RBC	WBC	RBC	WBC	RBC	WBC
2HR	270	360	600	1373	370	1133	150	1119
4HR	340	894	980	2220	680	1920	440	1793
6HR	400	960	1140	2713	730	2253	610	2113

RBC—IN THOUSANDS WBC—IN NUMBER OF CELLS

[1] This investigation is supported by research grant No. CY-3854 (C2) from the National Cancer Institute, National Institutes of Health, U. S. Public Health Service, Washington, D. C.

[2] Frederick R. Avis. *About Mice and Men: An Introduction to Mammalian Biology*. J. Weston Walch, Publisher, Portland, Maine. 1957.



GRAPH I. Oxygen uptake by liver and kidney tissue before and after six-hour perfusion.

dioxide in blood, and the spectrophotometer for such determinations as glucose in blood, glycogen content of liver, hemoglobin, etc. Since these experiments are challenging and involve more discipline, the students work harder in the laboratory and on written reports, taking more pride in and pains with their study.

Material gains in the science department undoubtedly will come as a result of the enthusiasm and confidence the local authorities develop when research is being recognized and carried out in their school laboratories. An excellent example of this is shown in the description of our new facilities which was presented in the February 1960 issue of *The Science Teacher*.

It is our fervent hope that the National Cancer Institute, other departments of the National Institutes of Health, and many institutes and industries will award grants to qualified secondary school science teachers for research. The impact on science education may well prove to be most significant for the future of our country.

For some time it has appeared important to design an apparatus which would simultaneously perfuse both a liver and kidney in such a manner that a continuous flow of blood would occur from the liver to the kidney and back to the liver. Such an apparatus could be used for demonstrating the effects of drugs upon these organs. Figure 1 presents a diagram of it, and various aspects of how it is used are discussed below.

1. *The maintenance of constant temperature:* The heating mechanism consists of a hot plate hooked into the thermoregulator circuit in series. The thermoregulator is a merc-to-merc thermometer regulator which is controlled by an electronic relay. A ten-gallon stainless steel pail with a tubular outlet at its base is placed on the hot plate. The blood reservoir is placed in this pail, and sufficient water is added to form a jacket around the reservoir. The water is drawn from the base of the pail by a centrifugal pump and circulated up through the outer jackets of the two West-type condensers and eventually up to the inner chamber of the Friedrich condenser where the overflow is returned to the pail. Each side of the apparatus has such a thermoregulating device for bovine perfusion. With this assembly, the blood is maintained within a limit of plus or minus two-tenths of a degree centigrade. The temperature is maintained at 38° C, the normal body temperature of cattle.

2. *The circulation of the blood:* Two liters of blood are used on each side of the apparatus for a normal dual perfusion. The blood reservoir consists of a 2-l Erlenmeyer flask which is placed within the stainless steel pail. The blood

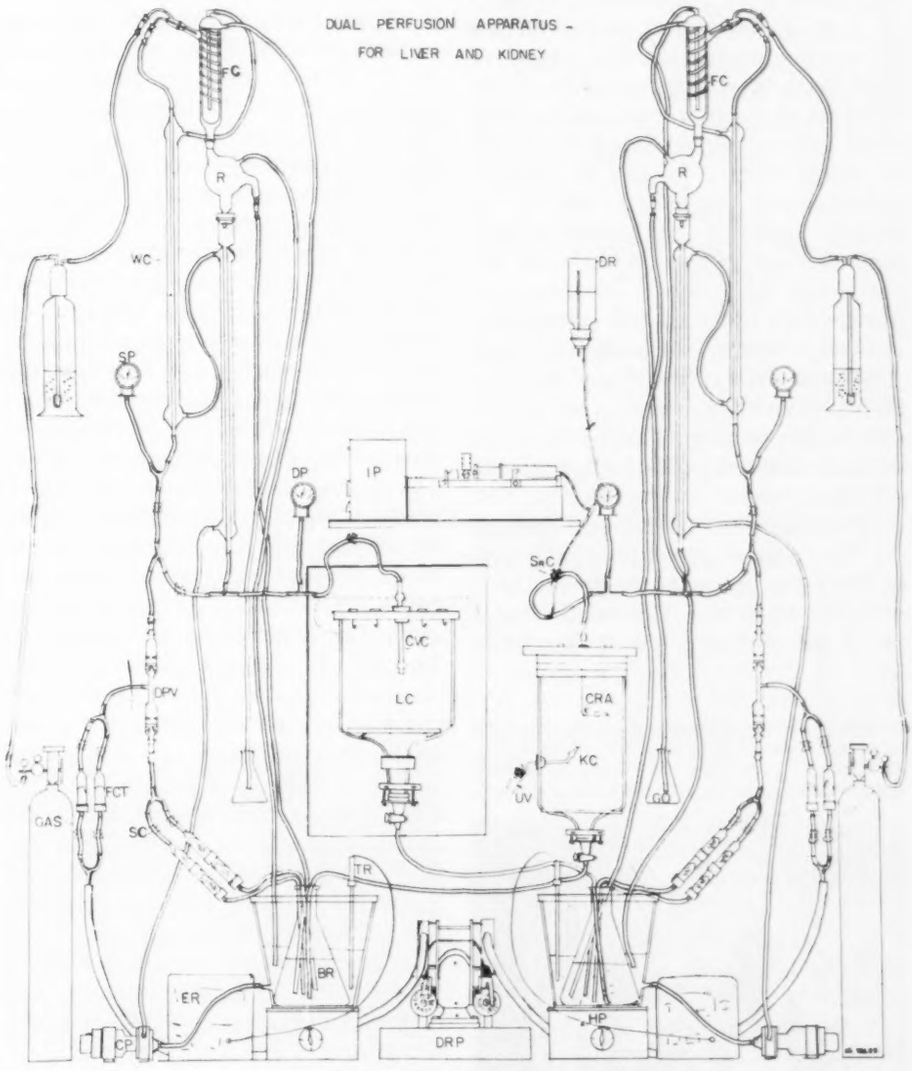


FIGURE 1. Assembled perfusion apparatus.

FC—Friedrich's condenser.
R—Reservoir.
WC—West type condenser.
SP—"Systolic" blood pressure manometer.
DP—"Diastolic" blood pressure manometer.
DPV—Double perfusion valve.
FCT—Finger cot.
SC—Spring clamp.
ER—Electronic relay.
CP—Centrifugal pump.
TR—Thermoregulator.
DRP—Dual respiratory pump.
LC—Liver chamber.
CVC—Cannula for inferior vena cava.
IP—Infusion pump.
DR—Drug reservoir.
SrC—Screw clamp.
CRA—Cannula for renal artery.
KC—Kidney chamber.
UV—Urine vial with ureteral cannula attached.
GO—Gas overflow.
NF—Nylon filter.
BR—Blood reservoir.
HP—Temco hot plate.

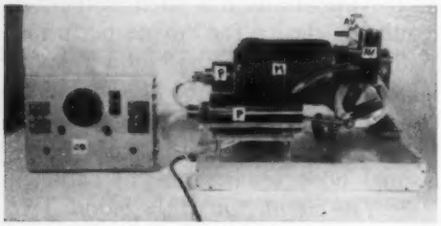
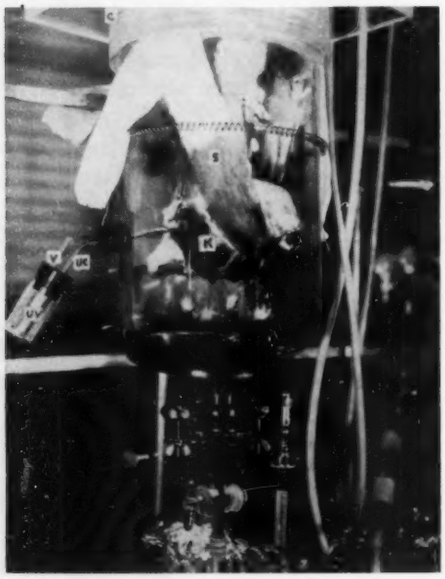


FIGURE 2. Dual Pump. CB—Electronic speed control box, P—Pistons, AV—Air valves, and M—Motor.

is filtered through a pair of nylon filters. The pumping action is regulated by a dual respiratory pump which consists of a third horsepower motor driving two pistons alternately. The output of each piston may be regulated by an adjustment of the piston rod to the drive shaft. The air output of each piston can be varied from 0 to 750 cc. Due to careful valve regulation, the air is sharply drawn in and expelled from each of these pistons, a desirable aspect when the pump is used for perfusion. Two hundred and seventy-five cc of air is injected and withdrawn from a medium sized rubber finger cot. The extension and contraction of the cot results in the pumping action on the blood which is transmitted through a double perfusion valve.

After blood has been drawn through the filter and passed through the perfusion valve, it enters the main blood stream. When the Y tube is placed above the perfusion valve, blood can take one of two pathways: one leads directly to the chamber which houses the organ and makes it possible to perfuse the organ directly when necessary; the second leads to a Y tube at the base of the West-type condenser. One arm of the Y tube leads to a blood pressure manometer and enables observation of the "systolic" pressure within the apparatus. This pressure is maintained at approximately 160 to 180 mm of mercury. From the West-type condenser the blood passes up through an arm into the Friedrich condenser at the top of the apparatus where it is ejected over the bevel plates of the inner chamber of the condenser. From here the blood passes directly into the reservoir, a modified 500-ml boiling flask which has two side arms. The top arm allows excess gas to pass off of the reservoir into a collecting vial attached to the side of the apparatus. The lower arm of the Y tube is for an overflow of blood and assures a continual level of blood in the reservoir. This is important in maintaining a constant pressure of the blood as it is conveyed by gravity to the organ. The blood passes down from this reservoir through a second West-type condenser and to the organ itself. The T tube is put in the line which conducts the blood to the organ. To the top of this tube is attached a second blood pressure manometer which records the "diastolic" pressure of the apparatus, maintained at 70 mm of mercury. In the apparatus, it is advisable to use latex rubber tubing. Because of its elasticity, less injury to the bloods cells occurs.

FIGURE 3. Kidney Chamber. C—Cover, S—Sling for kidney made of cloth tape, UV—Urine collecting vial, V—Vent tube, UC—Ureteral cannula, and K—Kidney.



3. *Oxygenation of the blood:* A mixture of 95 per cent oxygen and 5 per cent carbon dioxide is used. The gas flows at a rate of one l per minute and passes to a 500-ml gas-washing bottle which contains approximately 300 ml of distilled water. From the gas-washing bottle, the now moistened gas mixture is passed to the upper arm leading directly into the top of the Friedrich condenser. The lower arm carries the blood. The blood and gas are then mixed in the Friedrich condenser as the former passes over the bevel plate. In a dual perfusion, this method of oxygenation of the blood is duplicated on both sides of the apparatus. The flow of blood into the chamber which houses the organ is regulated by a screw clamp on the tubing leading directly to the cannula.

4. *The liver chamber:* The liver chamber consists of a five-gallon carboy from which the bottom has been removed and which is mounted on a standard wall bracket. The mouth of the carboy has a typical stopcock assembly. The floor of the chamber is covered by a porcelain-perforated desiccator plate. This helps to support the lower border of the liver. The cover of the liver chamber is a piece of heavy lucite, three-quarters of an inch thick. Six stainless steel buttons are distributed evenly around the 4.5-cm wide cannula entrance to the chamber. These buttons are perforated to hold silver wire which in turn is fastened to medium-sized fish hooks. The liver is suspended by the diaphragm, and the fish

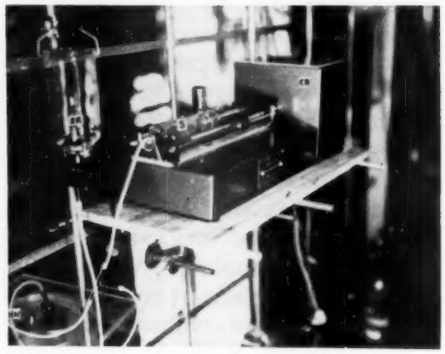


FIGURE 4. Infusion Pump. SR—Solution reservoir, HN—Hypodermic needle in tubing to kidney cannula, S—50-ml syringe, and CB—Control box for infusion pump.

hooks afford a fast, easy way of holding the liver close to the cover. The glass cannula for the liver, about four inches from the mouth, has a reservoir of approximately 10-ml capacity.

5. *The kidney chamber:* This chamber consists of a 9-l bottle which has had the bottom removed. The mouth of the bottle has a stopcock adaptor strapped to it in the same manner as the liver chamber. The cover for this chamber consists of a collar four inches high, with a three-quarter-inch top made of lucite. The bottom of the collar has a groove approximately one-quarter inch wide and one-eighth inch deep which makes it fit tightly over the rim of the bottle. A series of stainless steel buttons are arranged around the 4.5-cm wide cannula opening in the cover. These also have the same type of fish hooks attached to them as described above, and they are hooked into

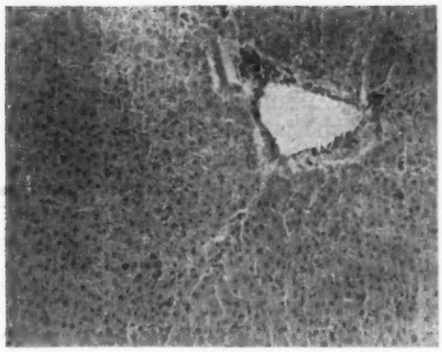


FIGURE 5. Liver tissue before perfusion. Hemotoxylin and eosin stain X220.

the renal capsule at the anterior pole of the kidney. It has been found, however, that as the perfusion proceeds, the capsule stretches. Consequently, the kidney is further supported by a cradle made of two crossed strips of cloth tape two inches wide. The posterior pole of the kidney is placed at the bottom of this sling and the strips are brought over the edges of the chamber. When the heavy top is placed down on these strips, its weight is sufficient to support the sling. This arrangement has the advantage of being sufficiently flexible so that adjustments can be made easily in the position of the kidney. The glass kidney cannula is nine inches long with a two-inch tip running at right angles to the main shaft. A small reservoir of 5-ml capacity is placed 1.5 inches from the mouth. The tip of the cannula is beveled and slightly enlarged to facilitate ligation of the renal arteries.

To collect the urine, a hole one inch in diameter is made approximately seven inches down from the upper rim of the bottle. The ureteral cannula with a split rubber stopper is placed through this opening. It extends beyond the outside of the chamber and is inserted in a two-holed rubber stopper. The other hole in the stopper houses a small glass vent. To this rubber stopper is attached a 20-ml vial. The ureteral cannula is made of glass tubing and has its tip curved slightly upward to enhance the flow of urine from the ureter to the glass vial. Having the vial on the outside of the chamber provides an advantage in collecting aliquots of urine and replacing the vial without disturbing the kidney.

6. *Infusion pump:* For the administration of saline to the kidney or drugs to the blood stream, an infusion pump is used. With this instrument, the rate of infusion may be varied from 0.0008 ml to 38.2 ml per minute in 72 equal steps. Variation is accomplished by using different-sized syringes and needles with various rates of speed. A saline or drug-reservoir attachment such as shown in Figure 1 makes it possible to refill the syringe without disassembling the pump.

7. *Preparation of the blood:* Four liters of blood are collected from the throat of the cow and poured through a gauze filter into a sterile bottle. For each liter of blood, this bottle contains 50 mg of heparin, 25,000 units of penicillin, and 62.5 mg of streptomycin which are dissolved in 25 ml of 0.8 per cent saline.

8. *Preparation of the organ for perfusion:*

a. *The liver:* Only the left lobe of the bovine liver, average weight equaling 1842 g, is used. A large segment of the diaphragm is set on the lobe to properly suspend the liver in the perfusion chamber. The inferior *vena cava* is brought up tightly around the cannula by using two purse-string sutures, one above the other. The major arteries and veins along the cut surface of the lobe are closed by wound clips. The margins of the liver are incised about a quarter to half an inch from the upper border to the cut surface. This strip is removed to enable a good flow of blood through the lobe. Until it is mounted on the apparatus, the organ is perfused by hand at the slaughterhouse with cold

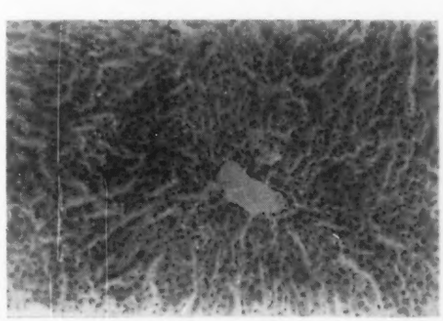


FIGURE 6. Liver tissue after perfusion. Hemotoxylin and eosin stain X220.

0.8 per cent NaCl solution that has been oxygenated for one hour.

b. Both kidneys are removed from the animal, and the renal arteries and veins are freed of fat. The cannulae are ligated in the renal arteries. The kidneys are perfused by hand with the same solution and by the same method as described for the liver. One kidney is used for perfusion. The other is used for histological sections and study of oxygen uptake as a control thus avoiding damage to the perfused kidney. The average weight of the kidneys used is 1186 g.

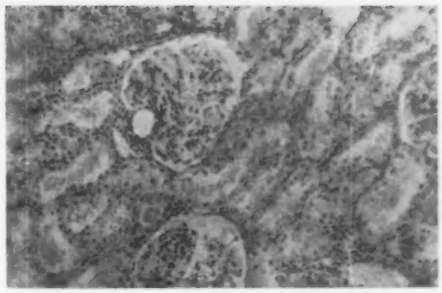


FIGURE 7. Cortical layer of kidney before perfusion. Hemotoxylin and eosin stain X220.

Effects of Apparatus on the Blood and Organs

The results discussed below are based on a total of 24 perfusions. Six, concerned with control, were carried out with blood alone circulated throughout the apparatus. Six were based on the perfusion of livers, six with the perfusion of kidneys, and six devoted to a dual perfusion involving both liver and kidney.

1. *Effects on the blood:* Table I shows the average drop in red and white cell counts during the six hours of perfusion. It is interesting to note that the effects on the cells form a rather definite pattern with the control showing the least amount of cellular destruction and the kidney perfusion the most. Liver perfusions in all cases are less deleterious to the cells than to the kidney. The dual perfusions consistently fell within the mean between the control and kidney effects.

Examination of the differential white cell counts shows that the neutrophils are affected the most. The liver and control have a drop of 13 per cent neutrophils and the kidney 14 per cent; with the dual perfusion, there is a drop of approximately 22 per cent. In considering these data one cannot help but suspect that the neutrophils rather than being destroyed in the apparatus are perhaps migrating into the tissue of the liver and kidney. The differential smears show no neutrophils undergoing degeneration. As the neutrophil count dropped, the lymphocyte

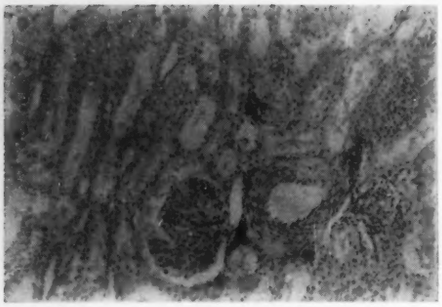


FIGURE 8. Cortical layer of kidney after perfusion. Hemotoxylin and eosin stain X220.

count rose correspondingly. By the end of the six hours of perfusion approximately 10 per cent of the lymphocytes showed degeneration either by rupture of the nuclear membrane or the cell membrane.

2. *The pH of the blood:* Since the pH shows little variation regardless of the type of perfusion involved, the pH determinations are averaged together for all perfusions. The average pH at the beginning of the experiments is 7.42, and the average drop at the end is 0.17. Care is taken to cover the plasma sample with mineral oil to prevent alteration due to CO_2. The determinations are made on a Coleman pH-Electrometer.

3. *Corpuscular volume:* In all four types of perfusions, the corpuscular volume tends to rise. The greatest change occurs with the kidney where an increase of 6.3 is observed. The least change in corpuscular volume is in the control with an increase of 2.3.

4. *Oxygen uptake of tissues before and after perfusions:* This technique is carried out on a Warburg Precision Apparatus. The water bath is maintained at 38° C. The modified Krebs-Ringer phosphate solution used is as follows: 100 parts of 0.9 per cent sodium chloride, 4 parts of 1.5 per cent potassium chloride, 1 part of 3.82 per cent magnesium sulfate with 7 molecules of water, 12 parts of a solution consisting of 3.55 g sodium phosphate plus 5 ml of one Normal hydrochloric acid diluted to a volume of 250 ml. This solution (Ringer) is not oxygenated nor is glucose added to it. Graph I illustrates the oxygen uptake of the tissues of the organs when the organs are perfused individually or simultaneously. The O_2 uptake shows little difference in either situation. All the organs except the kidney show some decrease in O_2 uptake after six hours of perfusion.

5. *Histological examination of tissues before and after perfusion:* Sections of the liver demonstrate little or no change in histological aspects. The blood vessels, hepatic cords, sinusoids, and endothelial cells all appear normal. Little or no hemorrhage is observed in the post-perfusion sections. (See Figures 5 and 6.) The cortex of the kidney shows very little alteration as a result of perfusion. (See Figures 7 and 8.) The glomeruli did not rupture, and the space between the capsule and the glomerulus is free of blood cells. The greatest change occurs in the medullary area where some hemorrhage is noted; however, this is not extensive.

6. *Urine:* The volume of urine obtained from the perfused kidney varies from 15 to 22 ml over the six-hour period. The urine is light amber; its odor is normal and its gross sediment is light. The specific gravity averages 1.030. It is of interest to note that the urine shows 0.25 per cent sugar by means of the quantitative Benedict test. This is undoubtedly due to the fact that the saline, with which the kidney is perfused previous to mounting it in the perfusion chamber, contains 1 per cent dextrose. By the end of two hours, this sugar has disappeared from the urine, and for the last four hours it remains at 0 per cent. Either the re-absorption mechanism of the kidney tubules is responsible for the withdrawal of the sugar—the organs may have metabolized it—or glycogenesis is taking place. The average pH of the urine is 7.0. The albumin is found to be from moderate to heavy in concentration. The microscopic sediment consistently has the same appearance. The red and white cells are found moderately heavy throughout, but at no time is clumping or clotting of either one observed. Salt crystals of any type are seldom seen. Epithelial cells are present, but most of these are ureteral which is probably due to cannulation of the urters. Casts, when present, contain either erythrocytes or epithelial cells. (Note: Throughout our experiments, care was taken to use the blood and organs from the same animal to avoid any possible problems concerned with incompatibility between the tissues and blood.)

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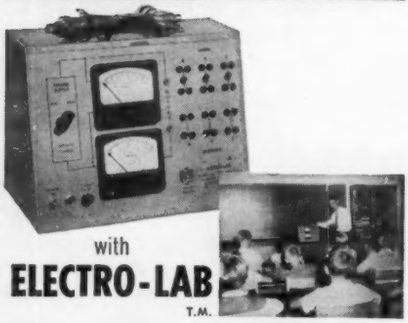

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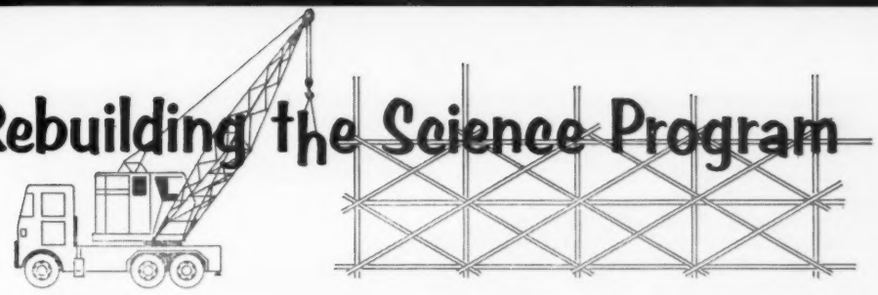
Summary

An instrument for the simultaneous perfusion of the bovine liver and kidney has been developed and refined so that it is easily adjusted to variations of blood pressure, blood temperature, and rate of flow. The administration of drugs to the organs may be varied from 0.0008 ml per minute up to 38.2 ml per minute in 72 equal steps.

Careful and extensive investigations have been carried out to establish the effects of the instrument on the organs, blood, and urine during six continuous hours of perfusion. No serious deleterious effects have been observed. Norms have been established for blood cells, pH of blood and urine, oxygen uptake of tissues, and urine.

NOTE: The authors wish to thank Dr. Murray J. Shear, Head of the Department of Chemical Pharmacology, National Cancer Institute, for his encouragement in the undertaking of this research program; James Carlo, a staff member of the Worcester Foundation for Experimental Biology, Shrewsbury, Massachusetts, for his helpful suggestions in the early stages of development of the perfusion apparatus; and Peter Tolos also of the Worcester Foundation for Experimental Biology for his drawing of the apparatus.



General

Science in the Curriculum

By SIDNEY DUSHMAN

Science Teacher, The Bronx High School of Science, New York City

THE level of scientific literacy has become an important measure of effective citizenship in recent years. In the light of this trend, it is increasingly important that the teaching of science be upgraded in our high schools.

What aspects of science are most significant in terms of the goals of general education? This question was aptly answered in the Harvard Report.[1]

> Science instruction in general education (in the secondary school) should be characterized mainly by broad integrative elements—the comparison and contrast of the individual sciences with one another, the relations of science with its own past, and with general human history, and of science with problems of human society. These are areas in which science can make a lasting contribution to the general education of all students. Unfortunately, these areas are slighted most often in modern teaching.

It was perhaps in response to the challenge implied in this last sentence that a course in the history and development of science was instituted at The Bronx High School of Science in 1947. The original course of study was drawn up by a committee consisting of teachers of biology, chemistry, physics, mathematics, and social studies. The approach was experimental, and many changes have been made through the years. Although the course was originally taught for one semester, five periods per week, it has recently been expanded into a two-semester course. Thus, it was possible to introduce considerably more science content. As the instructor, the author has found that science can be taught effectively, using a historical, development-of-concept approach. It can be made more meaningful by showing the interrelationships of the various sciences, and it can be made more stimulating by relating it to the culture in which it developed. In brief, science is more comprehensible and attractive to the student if it is presented as a unified body of knowledge, effectively integrated with history, economics, and the arts. An outline of the course follows:

First Semester

Unit I. Characteristics of Science.
- a. Definition
- b. Aims
- c. Basic Assumptions
- d. Limitations

Unit II. Pre-Hellenic Science.
- a. Babylonian
- b. Egyptian

Unit III. The Calendar.
- a. Need
- b. Celestial Phenomena Known to Ancient Man
- c. Egyptian and Babylonian Calendars
- d. Julian and Gregorian Calendars

Unit IV. Greek Science.
- a. Greek and Egyptian Cultures Compared
- b. Thales—The Ionian School
- c. Pythagoras—Mathematics
- d. Hippocrates—Medicine
- e. Democritus—Atomism
- f. The Golden Age of Culture
- g. Aristotle—The Encyclopedia
- h. Alexandrian Science
- i. Archimedes—Experimental Physics
- j. Ptolemy—Astronomy
- k. Galen—Anatomy
- l. Greek Slavery and Greek Science

Unit V. Geographic Orientation
- a. Fundamentals of Astronomy
- b. Ancient Concepts of Cosmography
- c. Determination of Latitude
- d. Determination of Longitude
- e. Eratosthenes—Determination of the Earth's Circumference

Unit VI. Decline of Science.
- a. Roman Empire
- b. Rise of Christianity
- c. Barbaric Invasions
- d. Rise of Islam

Unit VII. Reawakening of Science.
- a. Crusades
- b. Roger Bacon
- c. St. Thomas Aquinas and Scholasticism
- d. Discovery of the New World

Unit VIII. Cosmography.
- a. Copernicus
- b. Tycho Brahe
- c. Kepler

Unit IX. Scientific Revolution.
- a. Stevinus—Parallelograms of Force
- b. Galileo—Dynamics
- c. Huygens—Circular Motion
- d. Descartes—Coordinate Geometry
- e. Francis Bacon—Science and Society
- f. Newton—Law of Universal Gravitation
- g. Mechanism—Structure and Methods of Modern Science

Second Semester

Unit X. Light.
- a. Snell—Refraction
- b. Roemer—Speed of Light
- c. Newton—Corpuscular Theory, Color
- d. Huygens—Longitudinal Wave Theory
- e. Young and Fresnel—Transverse Wave Theory, Interference, Polarization
- f. Michelson and Morley—Is Space Absolute?

Unit XI. Gaseous State.
- a. Aristotle and Democritus—Ancient Concepts
- b. Industrial Revolution—Lift Pump
- c. Torricelli—"A Sea of Air"
- d. Pascal—Hydrostatics
- e. von Guericke—Air Pump
- f. Boyle—Pressure and Volume
- g. Charles—Pressure and Absolute Temperature
- h. Kinetic Theory of Gases

Unit XII. Combustion and Respiration.
- a. Aristotle—Four Elements
- b. Stahl—Phlogiston Theory
- c. Rey—Burning Tin
- d. Priestley—Oxygen
- e. Lavoisier—Oxidation

Unit XIII. Heat and Energy.
- a. Fahrenheit—Thermometer
- b. Black—Specific Heat, Heat of Fusion, Heat of Vaporization
- c. Caloric Theory
- d. Rumford—Kinetic Theory
- e. Joule—Heat and Energy

Unit XIV. Electricity.
- a. Gilbert—Electrics and Nonelectrics
- b. Franklin—One Fluid Theory
- c. Coulomb—Inverse Square Law
- d. Galvani—Animal Electricity
- e. Volta—Current Electricity
- f. Davy—Electricity and Chemistry
- g. Faraday—Electrolysis
- h. Oersted, Ampere, Faraday—Electromagnetic Induction

[1] Report of the Harvard Committee. Introduction by James B. Conant. *General Education in a Free Society*. Harvard University Press, Cambridge, Massachusetts. 1946. p. 155.

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- e. Newport—Frog Eggs Experiment
- f. Mendel—Segregation and Independent Assortment
- g. Flemming—Reduplication of Chromosomes in Mitosis
- h. Van Beneden—Reduction of Chromosome Number in Meiosis
- i. Weismann—Germ plasm and Somatoplasm
- j. De Vries—Mutation
- k. Sutton—Mendelism and the Gamete
- l. Morgan—Association of Factors
- m. Muller—X rays and Mutation
- n. DNA and the Gene

Unit XX. Evolution.
- a. Evidence for Evolutionary Concepts
- b. Malthus—Principles of Population
- c. Lamarck—Acquired Characteristics
- d. Charles Darwin—Origin of Species
- e. Impact on Society

Unit XXI. Recent Developments in Science.
- a. Nuclear Energy and Radioisotopes
- b. The Challenge of Space Travel
- c. Science and Technology
- d. Science and Government

Readings are assigned from the following books:

James B. Conant. *On Understanding Science*. Yale University Press, New Haven, Connecticut. 1947.

James B. Conant and L. K. Nash. *Harvard Case Histories in Experimental Science*. Harvard University Press, Cambridge, Massachusetts. 1957.

Mordecai L. Gabriel and Seymour Fogel. *Great Experiments in Biology*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1955.

Lancelot T. Hogben. *Science for the Citizen*. Fourth Edition Revised. W. W. Norton and Company, Inc., New York. 1957.

Sir James Hopwood Jeans. *Growth of Physical Science*. The Macmillan Company, New York. 1948.

Morris H. Shamos. *Great Experiments in Physics*. Henry Holt and Company, New York. 1959.

These books are supplemented by current articles in *Scientific American* concerning recent advances in science. Source material is drawn from the following:

William Francis Magie. *Source Book in Physics*. McGraw-Hill Book Company, Inc., New York. 1935.

Harlow Shapley and H. E. Howarth. *Source Book in Astronomy*. Harvard University Press, Cambridge, Massachusetts. 1959.

As in most other science courses, demonstrations are an integral part of instruction.

Historical Development

A brief review of some of the important developments in the history of science should be helpful in understanding the sequence and content of the course of study. Astronomy was the earliest of the sciences. The observations upon which its fundamental laws and theories were based are available and easily understood by the student. The logic of the early theories, in the light of the limited range of observations and experiences, are emphasized. The valuable role of astrology in the development of astronomy is cited as an example of how a false premise will often aid the development of science. As Francis Bacon wrote, "Truth will sooner come out of error than out of confusion." The need for an accurate clock for the determination of longitude was a stimulus to the study of dynamics. Copernicus' work in the sixteenth century coincided with the increasing need of the navigators for a new system of cosmography. Travel to the New World had made them keenly aware of the shortcomings of the Ptolemaic System.

Kepler and Galileo were contemporaries. While the former was developing his laws of planetary motion, the latter was elucidating the laws which were to become the foundation stones of the science of dynamics. Many historians of science believe that Galileo's interest in falling bodies was engendered by the introduction of artillery into warfare. So little was known in predicting the trajectory of a cannon ball that, apparently, its greatest effectiveness was as a psychological weapon rather than as a means of physical destruction.

In the latter part of the seventeenth century Newton effected the great synthesis of astronomy and mechanics, and modern science was born. The steps by which this process came about are not known, but Newton did give credit to the contributions of Kepler, Galileo, Descartes, and Huygens. The derivation of Kepler's second and third laws from Newton's Law of Universal Gravitation constitutes a good exercise in the application of mathematics to the solution of scientific problems and presents a good example of how new scientific problems give rise to new forms of mathematics. For instance, the study of accelerated motion sparked the development of the calculus. At this point, a re-examination of the methods, aims, and limitations of science is indicated. The course of study explores the impact of Newton's findings upon such aspects of contemporary society as politics, economics, literature, and philosophy.

Roemer's discovery in 1676 that light travels at a finite speed stimulated a tremendous interest in optics. Opposing concepts of light propagation provoked considerable study of the phenomena of color, diffraction, polarization, and interference. With bright students, the study of the comparative effectiveness of the various theories—corpuscular and wave—in explaining these phenomena can be pursued with profit. A good conceptual foundation for the later study of other electromagnetic phenomena can also be established at this time.

It appears that Galileo became interested in the study of the physical properties of gases when he found that bodies do *not* fall through the air with a constant acceleration. Within a year after Galileo's death, his pupil Torricelli reported that air pressure supported the mercury in his column. By 1660 almost all of the properties of gases and liquids which are studied in high school physics courses today were

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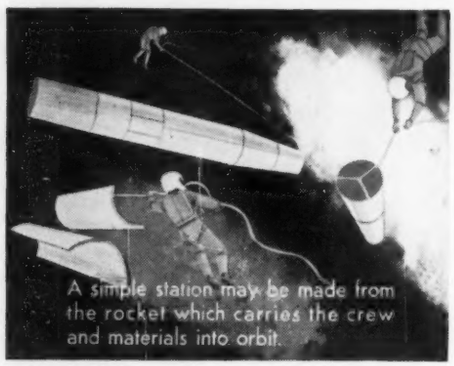

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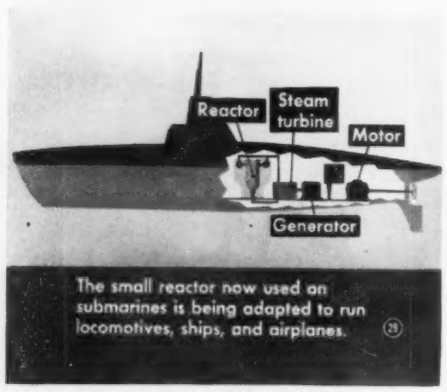

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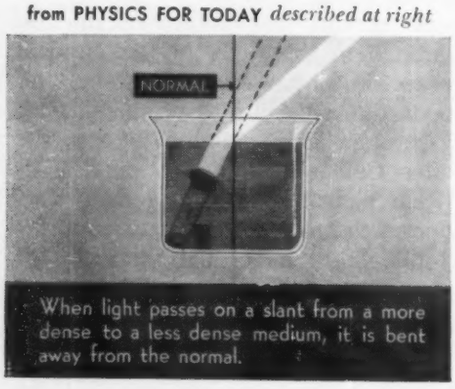

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known. The formulation of Charles' Law in 1787 had to wait the invention of a satisfactory thermometer.

Once a clear concept of gases was available, the science of chemistry could evolve from medieval alchemy. The phlogiston theory is studied, *not* as an example of pseudo-scientific bungling, but rather as a scientific attempt to develop a working concept inductively from a study of many related facts. It was modified to accommodate new findings, and finally, it was rejected when a more fruitful concept appeared. With the work of Lavoisier, the science of chemistry took on its modern aspect.

Up to this point, the student has not been exposed to the study of biology. While a wealth of facts regarding plants and animals had been accumulated before the eighteenth century, no productive hypotheses concerning them had been advanced, with the exception of Harvey's work on the circulation of blood. Just as chemistry too had to await the development of physics, so biology could not emerge as a science until chemistry had made an understanding of physiological processes possible. We should not underestimate the importance of the phlogiston theory in the development of biology during the eighteenth century. Priestley's reluctance to accept Lavoisier's concept of chemical change was due largely to the effectiveness of the phlogiston theory in explaining photosynthesis. By 1804, De Saussure had advanced our knowledge of this process to the level at which it is generally taught in high schools.

The development of the concept of the cell as the structural unit of living matter had to await the invention of the microscope. Although the term was first used by Robert Hooke in 1665, it was not until about 1840 that the cell theory evolved as a productive concept in biology. This was due mainly to the work of Schleiden and Schwann, both of whom stressed the role of the cell as a dynamic as well as a structural unit. It is interesting to note that Schwann became convinced of the validity of the cell theory while studying the development of the mammalian ovum.

An excellent example of controversy as a stimulus to the development of science is shown in the dispute opened by Redi in 1668, when he attacked the doctrine of spontaneous generation. The controversy raged for two centuries. But when it was laid to rest, the sciences of embryology, microbiology, and genetics were well established.

Biology, as an extensive and cohesive science of living things, came of age in 1859, when Charles Darwin in his *Origin of Species* presented a concept which gave purpose and direction to the vast complexity and diversity of life on earth. The biological sciences, each dissecting and analyzing, could now unite. From this new structure, each could draw new sustenance. The term "comparative" took on a richer meaning. We should recognize the contribution of geology in presenting evidence for the evolutionary concept. Darwin gave the geologists due credit, and in Malthus, Darwin found an exponent of sociology as a science.

The passage of time has given perspective to the influence of Darwin's work on contemporary culture. Religion, economics, literature, and higher education were buffeted by the waves of enthusiasm and of criticism engendered by the concept of biological evolution.

Following the great contributions of Newton, Lavoisier, and Darwin, the sciences of physics, chemistry, and biology grew so rapidly and in so many directions that it is difficult to trace any but the most obvious interactions of these disciplines.

Outline of Course of Study

This course is offered as an "elective" to seniors. That is, each senior is required to elect two from a slate of about sixteen courses offered by the science and mathematics departments. Between seventy and one hundred students enroll in this course each year, and each class contains about thirty-five.

All students have taken, or are taking simultaneously, courses in biology, chemistry, and physics, giving the curriculum a somewhat advanced character. The approach and the emphasis, however, are quite different from those of the required courses in science.

Student reaction to the course has been quite favorable. Quotations from their responses are cited:

> It serves to create a logical sequence in the important scientific discoveries, and, at the same time, gives a deeper understanding of the phenomena to the student.

> . . . it is an excellent background course in the three basic sciences and aids a great deal in preparing for more advanced college work.

> . . . by learning the development of early scientific theories, it was easier to understand the concepts of today. I found that the most stimulating class periods were spent studying contemporary scientific theory (*e.g.*, modern concept of the atom) or the effect of a particular theory upon contemporary society.

Criticism of the course called for "greater emphasis on historical material and less concentration on technical data," and "more discussion and correlation of the sciences to the times of their development." Several students complained of the lack of a single textbook. They found library work time-consuming. This last criticism brings us to a consideration of the difficulties to be overcome in conducting such a course. Although the lack of a single textbook places a burden on student and teacher alike, the wide scope of the course makes the selection of such a book unlikely and inadvisable. I have found that the ever-increasing number of inexpensive paperback reprints makes it possible for students to purchase several during the year. Ten or fifteen school copies of the more expensive books are exchanged among the students, one student in each class serving as librarian.

The content and emphasis of the course is determined by the following considerations:

1. The needs of the students.
2. The background of the students.
3. The intelligence of the students.
4. The background of the teacher.

Ideally, the course should be interdepartmental. Administrative difficulties, however, make this impractical. Although the author's background is mainly in the physical sciences, he finds that he receives considerable help from teachers in the areas of natural sciences and social studies.

In conclusion, experience with this course in the history and development of science offers convincing evidence that science content can be effectively taught as an evolving body of knowledge conerning natural phenomena. This knowledge can be shown to be an inherent part of the fabric of our culture.

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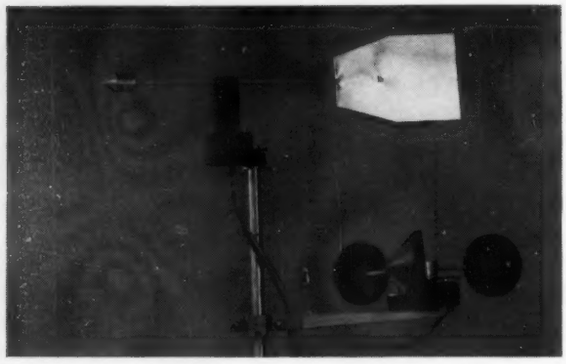

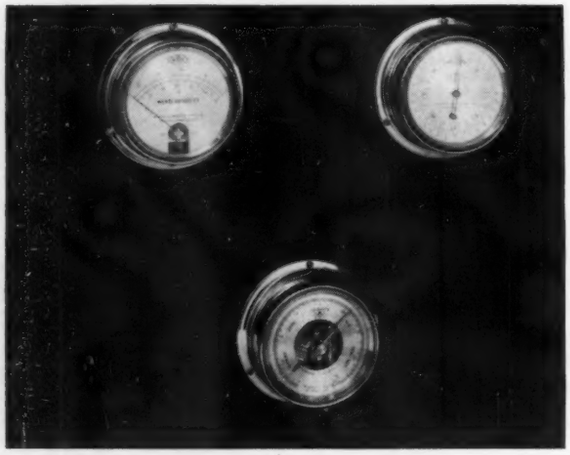

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Earth Science

Science Unit on Rocks and Minerals

By HENRY J. FOCACCI and THEODORE J. HUFF

Science Teachers, Public Schools, Paterson, New Jersey

I. Approach—An Introduction to Rocks and Minerals

Have you ever wondered how rocks were formed? Ever since the first man became curious about rocks (geology) and minerals (mineralogy), he has been fascinated by the mysteries of how and why they came to be.

During past millenniums, the earth has undergone many changes which have shaped the natural rock formations we witness today. Understanding the earth's structure and composition is a valuable asset in the study of rocks and minerals. There is a difference between superficial deposits and bedrock. Superficial deposits (1) include loose rock and soil which make up the outer surface of the earth's crust; bedrock (2) is the solid rock beneath, grading downward to the earth's mantle (3), and eventually to its core (4). The fundamental nature of these layers was illustrated and discussed in an article by G. P. Woollard in the September 1960 issue of *The Science Teacher*.

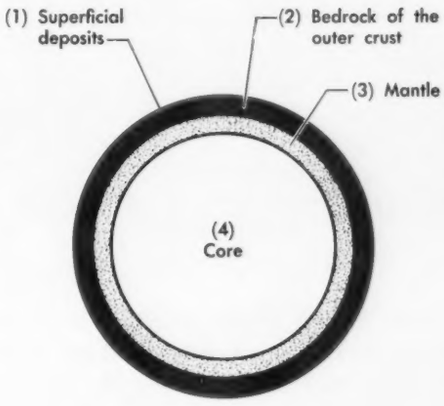

FIGURE 1.

It is this bedrock, divided into the three categories called igneous, sedimentary, and metamorphic, with which we are mainly concerned here.

Igneous rock, which is Latin for "fire" rock, is the basic stuff from which all other rock formations are eventually derived. These rocks are the solid (frozen) equivalents of volcanic lavas and other once-molten substances. They cover large areas of the earth and have such names as granite, diorite, pumice, pegmatite, obsidian, felsite, and basalt.

The weathering or breakdown of igneous rock by wind, water, and glaciers causes certain sediments to be washed away and later deposited elsewhere. The conglomeration and cementing of these sediments, or the crystallization of substances from solution in seas or lakes, form our second group of rocks, called sedimentary rock. These rocks, many of which contain fossils, are characteristically stratified. Shale, limestone, sandstone, coal, and conglomerate are examples of sedimentary rock.

Due to the pressure, increased temperature, and chemical action affecting igneous and sedimentary rocks that are deeply buried or squeezed by mountain-building processes, we now have the third type of rock called metamorphic from the Latin word signifying that this rock has undergone change in texture and mineral composition. Metamorphic rocks are ordinarily banded or laminated and commonly compact and crystalline. Examples are slate, gneiss, marble, and quartzite.

Rocks are composed of one or more minerals or mixtures of minerals. A mineral, on the other hand, is composed of a fixed arrangement of compounds or elements. Minerals are commonly

Igneous Rock. Volcano Ngauruhoe, New Zealand, in eruption (A). A new lava flow (volcanic rock made "yesterday") on the slopes of Ngauruhoe (B).

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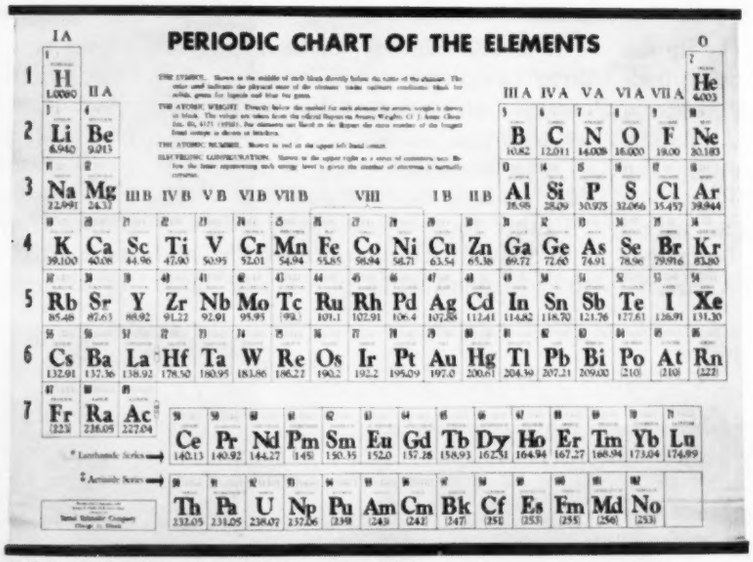

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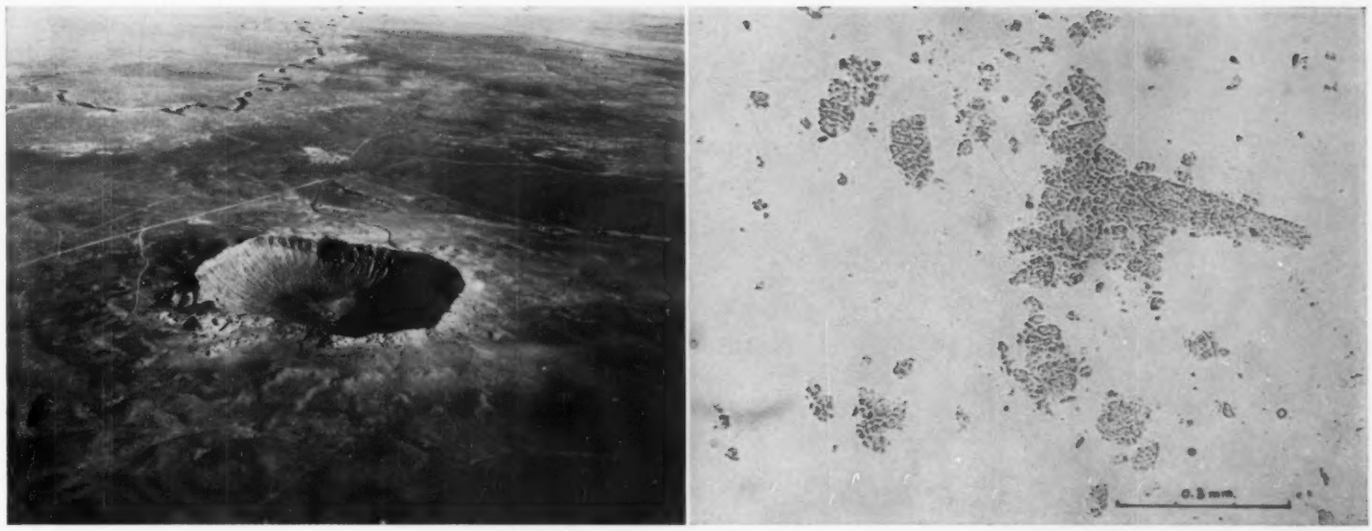

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Metamorphic Rock and Mineral. Meteor Crater, Arizona (left). Heat and pressure generated by meteoric impact at this place altered the bedrock sandstone and changed some of its quartz to coesite, a high pressure form of SiO_2 until recently known only from laboratory synthesis. (Right) Some of the mineral coesite found at Meteor Crater and first reported in July 1960 by E. T. C. Chao, E. M. Shoemaker, and B. M. Madsen of the United States Geological Survey.

crystallized. Throughout the centuries, minerals and rocks have served man as raw materials, tools, sources of energy, and for decorative and other purposes. Some well-known minerals are salt, diamond, topaz, quartz, feldspar, fluorite, calcite, gypsum, and talc.

Closely related to rocks and minerals are ores which are rock or mineral deposits from which metals such as gold, silver, copper, platinum, or lead can be obtained commercially.

II. General Objectives

1. To develop a consciousness of the importance of rocks and minerals.
2. To explore this area of rocks and minerals.
3. To understand the three major classes of rocks, their classifications, and uses.
4. To provide experiences which will give practice in developing skills and habits in understanding and appreciating the uses of rocks and minerals.

III. Specific Objectives

1. To understand how rocks are formed.
2. To acquire a knowledge of the general characteristics of rocks and minerals.
3. To learn how rocks and minerals are related to other things in nature.
4. To understand what fossils are.
5. To ascertain how important rocks and minerals are to the earth.
6. To understand how man has learned to use rocks and minerals.

IV. Skills

1. Develop ability to think, evaluate, write, and speak clearly, constructively, and creatively about rocks and minerals.
2. Learn to comprehend vocabulary necessary to the unit of study and to spell terms correctly.
3. Develop ability to read critically the material in this area of study.
4. Develop ability to express oneself through illustrative material.

V. Habits

1. Develop good work and study habits.
2. Develop the habit of working with others.
3. Develop the habit of reading purposive writings.
4. Develop the habit of collecting and organizing data.
5. Develop the habit of perseverance.
6. Develop the habit of being a resourceful person.
7. Develop the habit of being an original thinker and planner.
8. Develop the habit of dependability and accuracy.
9. Develop the habit of using good oral and written language.
10. Develop the habit of checking evidence before forming a conclusion.

VI. Attitudes

1. Pupil becomes aware of the importance of rocks and minerals.
2. Pupil learns to be persistent in his search for truth about rocks and minerals.
3. Pupil learns to keep an open mind about scientific knowledge relating to the study of rocks and minerals.
4. Pupil learns the value of the scientific method in general problem solving.
5. Pupil acquires intellectual curiosity about rocks and minerals and their relationship to other forces of nature.
6. Pupil learns the need to go to reliable sources for information and to formulate tests of reliability.

VII. Known Concepts

1. Superficial deposits consist of loose rock and soil which make up the outer surface of the earth's crust.
2. Bedrock consists of the solid rock beneath.
3. Igneous rocks are made by heat.
4. Sedimentary rocks are formed from sediment deposited from water, air, or ice.
5. Metamorphic rocks are igneous and sedimentary rocks changed by heat and pressure.
6. Some minerals are more useful to man than others.
7. Rocks are used for many pur-

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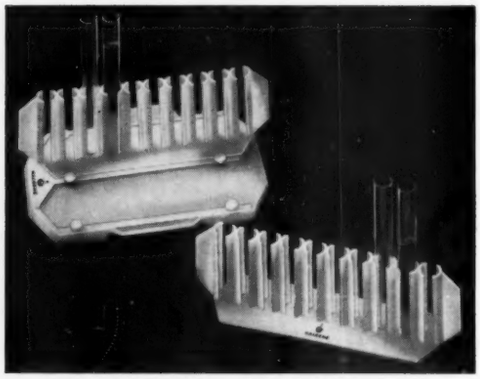

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poses including building materials, road making, and industrial uses.

8. Fossils are the stony remains or impressions of animals and plants in the rock.

9. Minerals are pure, commonly crystallized substances, many of which are useful to man.

10. Ores are rock or mineral deposits from which metals can be produced commercially.

11. Some rocks and minerals can be used as jewels.

12. Igneous rocks are the solid equivalents of once-molten substances. They are commonly massive and crystalline.

13. Sedimentary rocks are stratified.

14. Metamorphic rocks are characteristically massive or foliated.

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Sedimentary rock more than two hundred million years old in the Grand Canyon.

VIII. Concepts to Be Developed

1. Rocks and minerals can be identified in various ways.

2. Rocks are the building material of which the earth is composed.

3. Rocks are commonly made of mineral crystals which have grown together.

4. Minerals are naturally occurring substances having a definite chemical composition and characteristic physical structure.

5. There are thousands of kinds of minerals and hundreds of kinds of rocks.

6. Luster, color, and crystal form characterize the general surface appearance of minerals.

7. Hardness is the resistance that certain minerals have to being scratched by other substances.

8. Cleavage is the smooth breakage of a mineral in given directions.

9. Fracture is the state of a mineral breaking unevenly and not along cleavage surfaces.

10. The streak of a mineral is the mark made by testing it on the back of a piece of tile or unglazed porcelain.

11. Some minerals fluoresce under ultraviolet light; the luminescence of certain types can be produced through the rays of such lights.

IX. Activities, Observations, Experiments

1. List the vocabulary that relates to the unit of study.

2. Make a chart of the more common rocks and minerals, their uses and their characteristics.

3. Keep a record of current news items about rocks and minerals and their uses in the world today.

4. Arrange a display of rocks and minerals with proper labels for identification.

5. Read information about rocks and minerals from various sources such as science texts, supplementary science materials, encyclopedias, etc.

6. Conduct a class discussion and demonstration of the following:

While investigating the various means of identifying minerals, it is necessary to notice the particular characteristics possessed by them: luster, color, hardness, cleavage, fracture, and specific gravity.

Luster and color, which are produced through various means, pertain to the general surface appearance of minerals. These two features are very closely allied.

Hardness is the resistance that certain minerals have to being scratched by other substances. Diamonds can be scratched only by other diamonds; jade can be scratched by quartz; gypsum by fingernails; calcite by a penny; feldspar by a sharp knife; and quartz by a hardened steel file.

Cleavage is the smooth breakage of a mineral in given directions. Mica, a perfect example of cleavage, can be peeled into very thin sheets.

Fracture, on the other hand, is the state of a mineral breaking unevenly without any definite direction.

The power of magnetism influences some minerals that contain iron, nickel, or cobalt.

7. Place some small chips of granite secured from a quarry or a stonecutter in a small muslin bag and strike the bag several times with a hammer. Examine the powdered fragments under a magnifying glass. The little shiny flakes will be mica; the white and pink particles will be quartz and feldspar.

8. Figure the specific gravity of a mineral—the ratio of the weight of a mineral to the weight of the same volume of water. Weigh the mineral and then drop it into a graduated container partly filled with water. Read the volume of water displaced. This is also the volume of the mineral. One cubic centimeter (or, better, milliliter) of water weighs almost exactly one gram. Divide the weight of the mineral by the volume to discover how much one cubic centimeter would weigh, and this (divided by one) is the specific gravity. This is one of the best clues for identifying a pure mineral.

9. Through a class project, investigate the following facts about luminescence. One of the most fascinating characteristics of minerals is their ability to glow in the dark. There are different ways in which minerals can glow, and some give an added clue to identity. The luminescence may be fluorescent, phosphorescent, thermoluminescent, or triboluminescent. Scheelite, for example, may fluoresce

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Albert Einstein

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bright blue. Phosphorescence occurs when the mineral continues to glow after it has been exposed to an ultraviolet light and the light has been turned off (for example, willemite). Thermoluminescence applies to the condition where the mineral, when heated, gives off light in a darkened room. Triboluminescence occurs when a mineral, scratched in the dark, shows a line of light, as does sphalerite. Place several small pieces of fluorite in a baking dish with a glass cover and heat gently. The pieces of fluorite will bounce about giving off sparks of light.

10. Explain the difference between tenacity and hardness. Tenacity differs from hardness in a mineral. It is the way a mineral holds together. Jade has tenacity, for example. A diamond is hard, yet if struck with force it can be shattered.

11. Discover the oddities among minerals and rocks. Find the meaning and uses of such minerals as garlic stones, seeing-eye metal, weather stone, magnetic stone, cryolite, and gastroliths.

12. To test for calcite, place a few drops of cold, diluted hydrochloric acid on calcite. Bubbles of carbon dioxide will appear, showing that the mineral is a carbonate (contains CO_3). Or test a piece of granite with hydrochloric acid and notice that it does not bubble.

13. Take the class to a museum to see rocks, minerals, and fossils.

14. Make collections of pictures showing rock being quarried for building purposes.

15. Explore a quarry in your neighborhood. Examine the rock ledges exposed. Investigate uses made of rocks in your locality.

16. Show that sandstone is porous. Weigh a dry piece, and then let it soak in water overnight. Weigh it again after you have wiped off any drops of water on the surface. The increased weight is due to water that has occupied pore spaces in the rock. How could you estimate volume of pore space from this?

17. Have a glass jar of water ready. In another dish mix sand, pebbles, small shells, and fine clay or dust. Pour the mixture into the water, and let it settle. Does it settle in layers?

18. You may make an impression of a fossil by pressing a shell or a piece of fern between two layers of clay or plasticene. When you separate the layers, the shell or fern lies on one, and the mark it made shows its shape on the other.

X. Visual Aids

1. Use of films and filmstrips to tell the story of rocks and minerals and their usefulness to man.

2. Use of the opaque projector to show pictures of rocks and minerals.

3. Use of pictures from magazines and other sources to explain rocks, minerals, and their uses.

4. Use of models of building materials from rocks and minerals, as well as actual specimens of rocks and minerals.

5. Making posters and charts illustrating facts about the field of study.

6. Assembling materials and equipment for various experiments with rocks and minerals.

XI. Materials

Specimens of rocks and minerals; acid (vinegar, lemon juice, or hydrochloric); oak tag paper; construction paper; butcher paper for posters and charts and for sketches and diagrams of rocks and minerals; clay or plasticene; shells; plant leaves; small pans; water; ultraviolet light; display boxes and trays for rocks and minerals; and any other materials needed for experiments and activities listed in this unit of study.

XII. Evaluation

The students were able to discuss major learnings of the unit in class, in a written examination, and in a culminating unit activity—an assembly program entitled "The Earth's Crust." Not only did they learn about rocks and minerals and their importance to man, but many pupils also became interested in rock collecting outside of class time. They felt they would be better collectors since they had acquired a background of knowledge in the identification of rocks and minerals.

The teacher observed that the general and specific objectives of the unit were achieved. Major concepts were developed through pupil participation in experiments and in class activities. Since the study of rocks and minerals was interesting to the pupils, the author believes considerable understanding, enjoyment, and a beneficial approach to scientific problem solving were derived from the unit.

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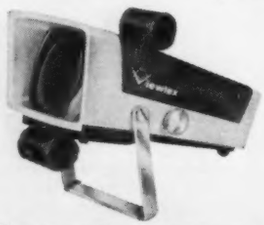

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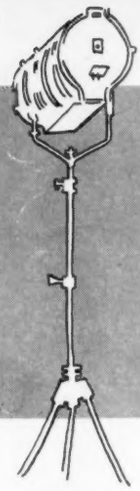

Evaluating Critical Thinking in Science

By JAMES J. REILLY

Assistant Dean, School of Education, St. John's University, Brooklyn, New York

MANY teachers have been vitally interested in the interplay between theory and empirical investigation as it relates to science teaching. The advent of teaching machines and canned courses heightens the concern of those who feel that thinking and experimentation by students should be promoted rather vigorously, whereas rote memorization should be minimized. How do we distinguish between the youngster who can regurgitate, upon demand, Newton's Third Law of Motion and the youngster who "knows" in an insightful manner what is involved? How do we measure a youngster's ability to apply knowledge in a situation not directly learned in the classroom? Some attempts have been made to answer these questions but they seem to have fallen rather wide of the mark. In this article, some empirical data is presented which may suggest an approach to one of the phases of critical thinking. Clearly, the evaluating (testing) of critical thinking in science is directly related to the teaching of critical thinking in science. The presumption is that this is a desirable objective and is being pursued—vigorously—in the classroom.

Essentially, what we do is to develop a "test-retest" situation in which the students respond to two different types of instruments which are based on the same content materials or learning situations. The Dunning Physics Test was administered to three hundred freshmen at three different colleges. The "retest" to this population involved the following. A Science Scrapbook was prepared and reproduced realistically by photo offset. It contained forty newspaper clippings matched in content or idea to forty corresponding items in the Dunning Test. The student population was asked to "agree" or "disagree" with the accuracy of each of the newspaper clippings. The investigator already knew how the youngsters scored on the Dunning Test. An example will help clarify the structure.

Dunning Item

Of the following, the most penetrating form of radiation is:

ultraviolet light
heat
cosmic rays
X rays
infrared light

Scrapbook Item

Washington, D. C., Dec. 9. The National Cancer Research Foundation, with funds collected throughout the United States during the past several years, today accepted from a private electrical company a new X-ray machine. X rays are, of course, the most penetrating form of radiation and it is hoped that the new machine will aid substantially in the continuing fight against cancer.

Most of the items are somewhat less factual in content and this one is presented merely by way of example. The development of the items was a "con-

trolled situation" throughout the exercise. Space does not permit a description of the nature of these controls, but the interested reader is referred to the basic reference (1).

In addition to performance on the two instruments described, all testees were investigated in the light of other factors. Intelligence test scores (California Test of Mental Maturity) were included. What is the relationship between "intelligence" scores and the ability to see the relationship between known facts and those same facts "as they operate" in a situation seen for the first time? Specifically, what is the correlation between intelligence and critical-thinking skills? Research studies indicate "a tendency to cluster around .45." The more than casual reader is invited to examine *Explorations in Evaluation* by Dressel and Mayhew (2). In this study the investigator found a correlation of .39 between intelligence scores and Scrapbook performance.

Glaser did a pioneering piece of work in 1941 (3) and, of course, the *Watson-Glaser Tests of Critical Thinking* (4) are some of the very few serious testing instruments available. The consistency of the responses from research findings of all serious investigators leads to the somewhat obvious conclusion (research confirms what we already suspect!) that intelligence tests do *NOT* measure critical-thinking skills.

What of the relationship between critical-thinking skills and reading and vocabulary? It is common knowledge that some intelligence tests are heavily loaded with a "verbal" factor. A priori reasoning would lead us to suspect that no necessary relationship exists between critical-thinking skills and verbal ability. The empirical data confirms this. The correlation between the Cooperative Reading Test and the performance on the Science Scrapbook was .14; that between Vocabulary versus Scrapbook was .20; and that between Vocabulary (science sub-test) versus Scrapbook was .33.

A final factor investigated was spatial-relations ability. In the language of the psychologist this is a "pure" factor and it would be informative to relate ability in this area to performance on the Scrapbook. Using the Minnesota Spatial Relations Test, the correlation was found to be .18.

In sophisticated terms, we have been discussing "critical thinking and psychometric design." The question is how do these relate to the classroom science teacher? It is believed that there is a direct relationship. Some engineering schools and science centers spend considerable time, money, and energy in attempting to develop in their students an active creative imagination and critical-thinking ability. At the secondary school level, these same activities may be introduced. This article suggests one way. A bright group in any science area would have a "field day" working cooperatively with a teacher in such activity. An insightful and resourceful teacher could use the development of the items itself as "the test situation." As indicated previously, with the advent of "programmed teaching" in science the need for imaginative evaluation with some degree of statistical sophistication becomes increasingly obvious.

What has been suggested here is simply "an approach" to the problem. As the mechanization of the process becomes more prevalent, as "the facts of the case" become increasingly easier to disseminate, science teachers—as indeed all teachers—need to become increasingly more sensitive to their responsibility in the matter of total evaluation of their charges. The classroom teacher, in science as elsewhere, is the critical factor when it comes to the development of and the evaluation of critical-thinking ability. National testing and teaching programs make it a matter of *(hic et nunc)* here and now.

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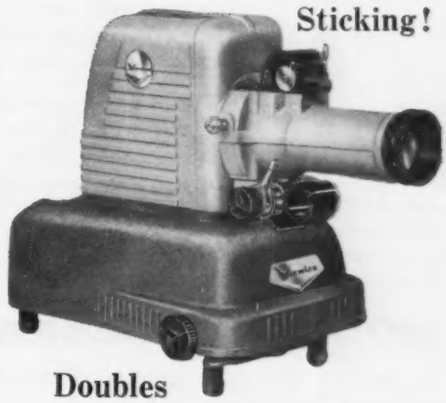

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Classroom IDEAS

Physics

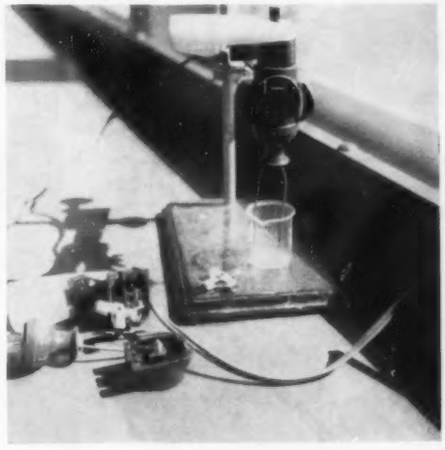
Conductivity Apparatus

By RICHARD L. HUTCHENS, Clackamas High School, Milwaukie, Oregon

This report was an entry in the STAR (Science Teacher Achievement Recognition) awards program of 1960, conducted by NSTA and sponsored by the National Cancer Institute, U. S. Public Health Service.

Since an understanding of conductivity is essential to an understanding of ionization, the author has sought for several years to demonstrate conductivity through individual student experiments. Since the apparatus and some of the organic reagents required for the work are quite expensive, it was found impractical to conduct the experiment when required for classroom lots on a macro scale.

During current classes, construction was begun of a relatively inexpensive apparatus which can be used on a semimicro scale by pairs of students in the classroom. The parts for twelve pieces of the conductivity apparatus—enough for one outfit to each two students—cost about $16. The assembly, with student help, was constructed in about two hours. Required for each piece were one night light, one short length of extension cord with a three-way receptacle on one end and a plug on the other, another plug, heavy gauge copper wire, electrical tape, soldering equipment, and a 20-ml beaker.



After assembly of the complete apparatus, students may view carefully before use in experiments.

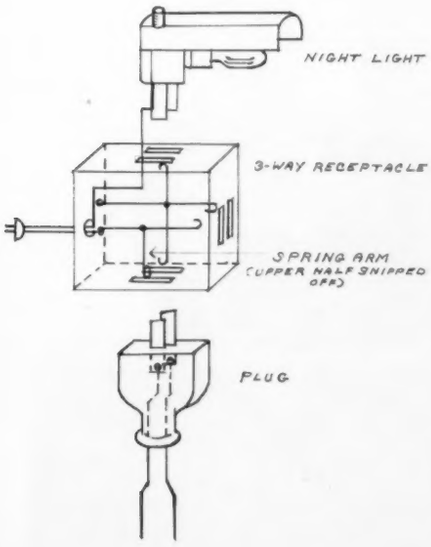


FIGURE 1.

The assembly is quite simple, but it is necessary to make one alteration in the three-way receptacle so that the night light (attached directly) will be in series with the electrodes. (See Figure 1.) The class accomplished this by snipping off one of the spring arms which would normally make contact with one of the lamp's plugs and then soldering one of the leads directly to the cut-off arm. Although this is the simplest method of attachment, it does have the disadvantage of permanently mounting the lamp onto the receptacle. Students should be cautioned, however, to avoid mounting the plug containing the electrodes permanently to the receptacle since this would make replacement of the electrodes more difficult.

After assembly the whole apparatus was attached to a ring stand with a universal clamp, and the solutions to be tested were placed in a 20-ml beaker.

Biology

Miniature Plants in the Classroom

By WILLIAM G. THOMAS, W. H. Kirk Junior High School, East Cleveland, Ohio

This report was an entry in the STAR (Science Teacher Achievement Recognition) awards program of 1960, conducted by NSTA and sponsored by the National Cancer Institute, U. S. Public Health Service.

To replace the usual decorative plants displayed in many classrooms, the author has substituted miniature plants such as corn, tomato, muskmelon, watermelon, and roses for demonstration purposes.

Countless generations of science students have watched corn and bean seeds germinate, but eventually the young plants have to be disposed of due to space limitations. In spite of our modern transportation systems, many city-bred students never have the opportunity to observe food and other plants actually growing. One wonders if they are left with the impression that corn and beans never grow any larger. Anything they learn about these common plants, other than facts about germination, must be gleaned from textbooks. Although they read about brace roots, they never have the opportunity to see them.

The project of observing plant development should be used as a supplementary but continuing unit rather than one covering merely a two- or three-week period. The seeds are started in eighteen-inch planters, each containing four plants. These planters are small enough to be moved and observed by the students. Since the plants reach maturity in about ninety days, the study unit easily fits into one semester. As the plants develop, as much time as is needed is taken from the regular class

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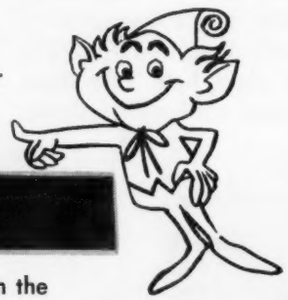

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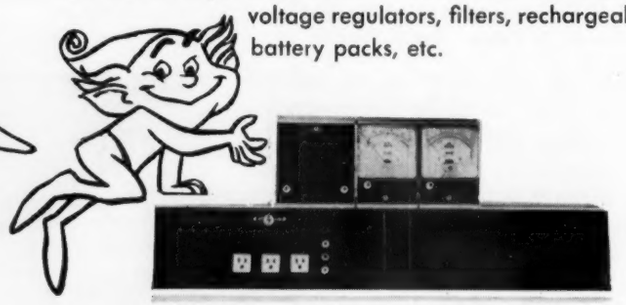

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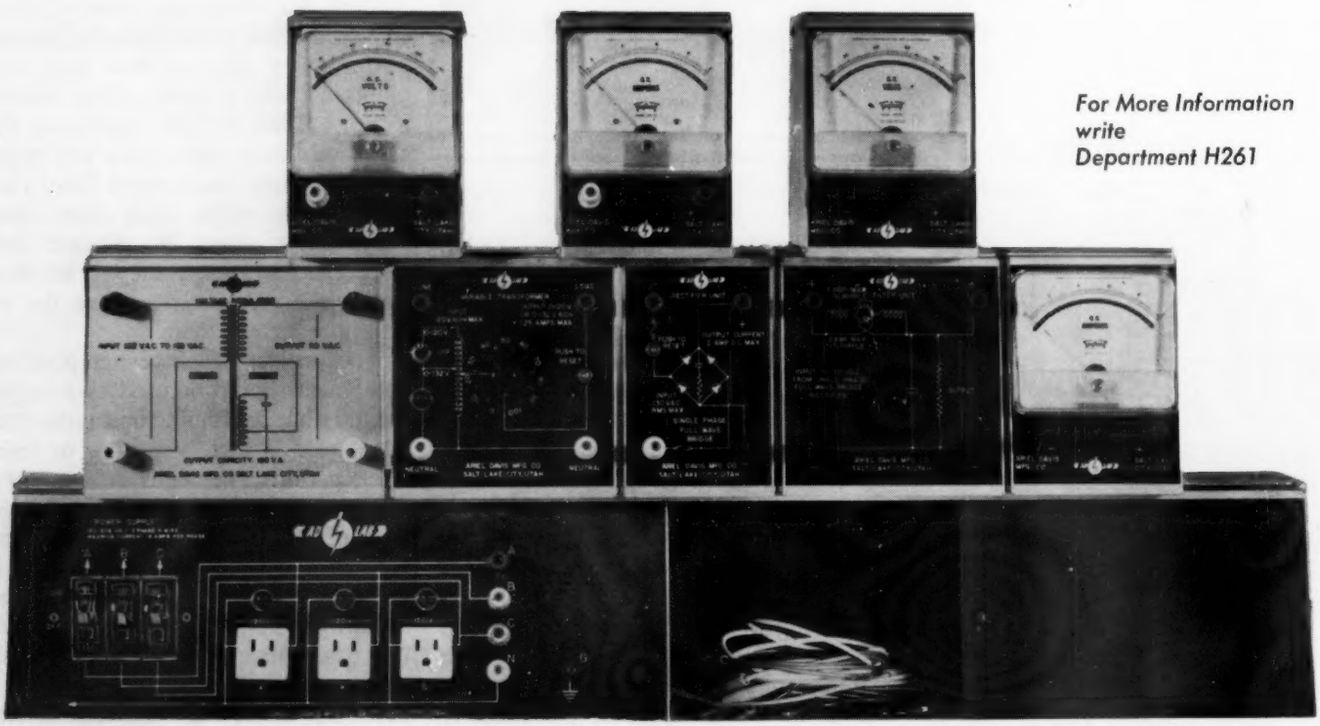

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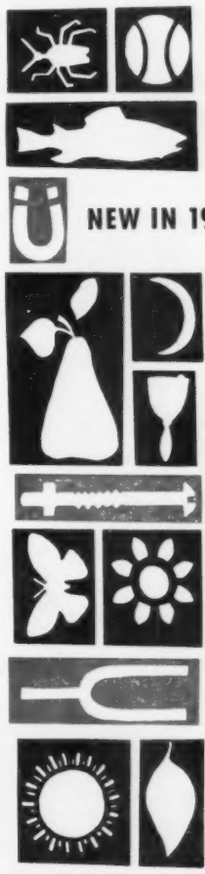
period to explain and discuss each stage. This may range from five minutes to several periods.

Observation of plant development should include the following:

1. Germination and development of cotyledons.
2. Types of roots.
   a. Regular.
   b. Adventitious.
3. Leaf formations.
4. Stem types.
5. Flowers.
   a. Separate flowers on corn.
   b. Complete flowers on tomato and muskmelon.
6. Pollination (hand pollination may be practiced).
7. Types of fruit. The fruit as it develops never fails to be a source of extreme interest to the students.

These plants are so small that the corn, for example, never reaches a height of more than thirty inches. The fruit, of course, is proportionately smaller. The purpose of the project, however, is not to raise a profitable crop, but to give the students an opportunity to observe common plants as they grow and develop.



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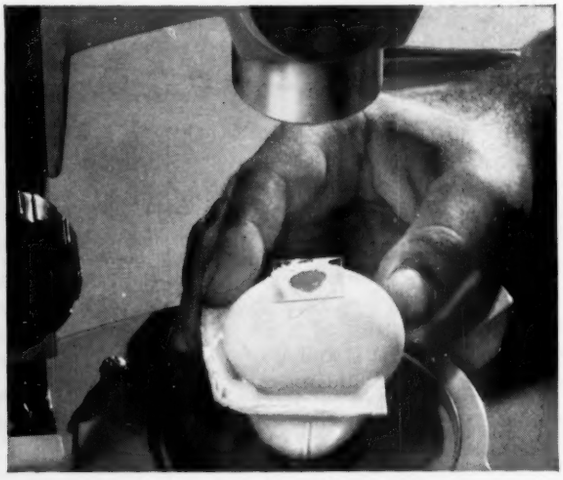

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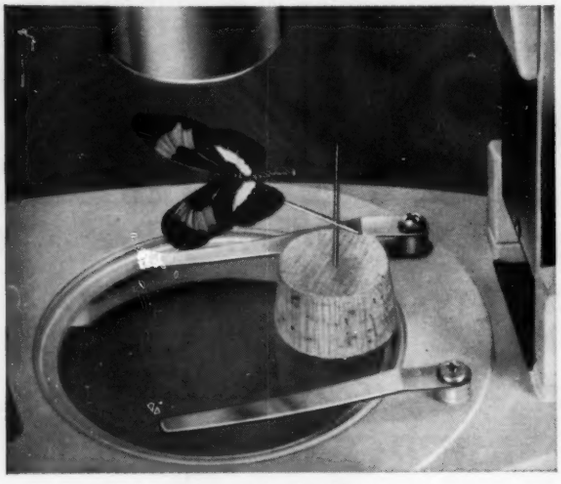

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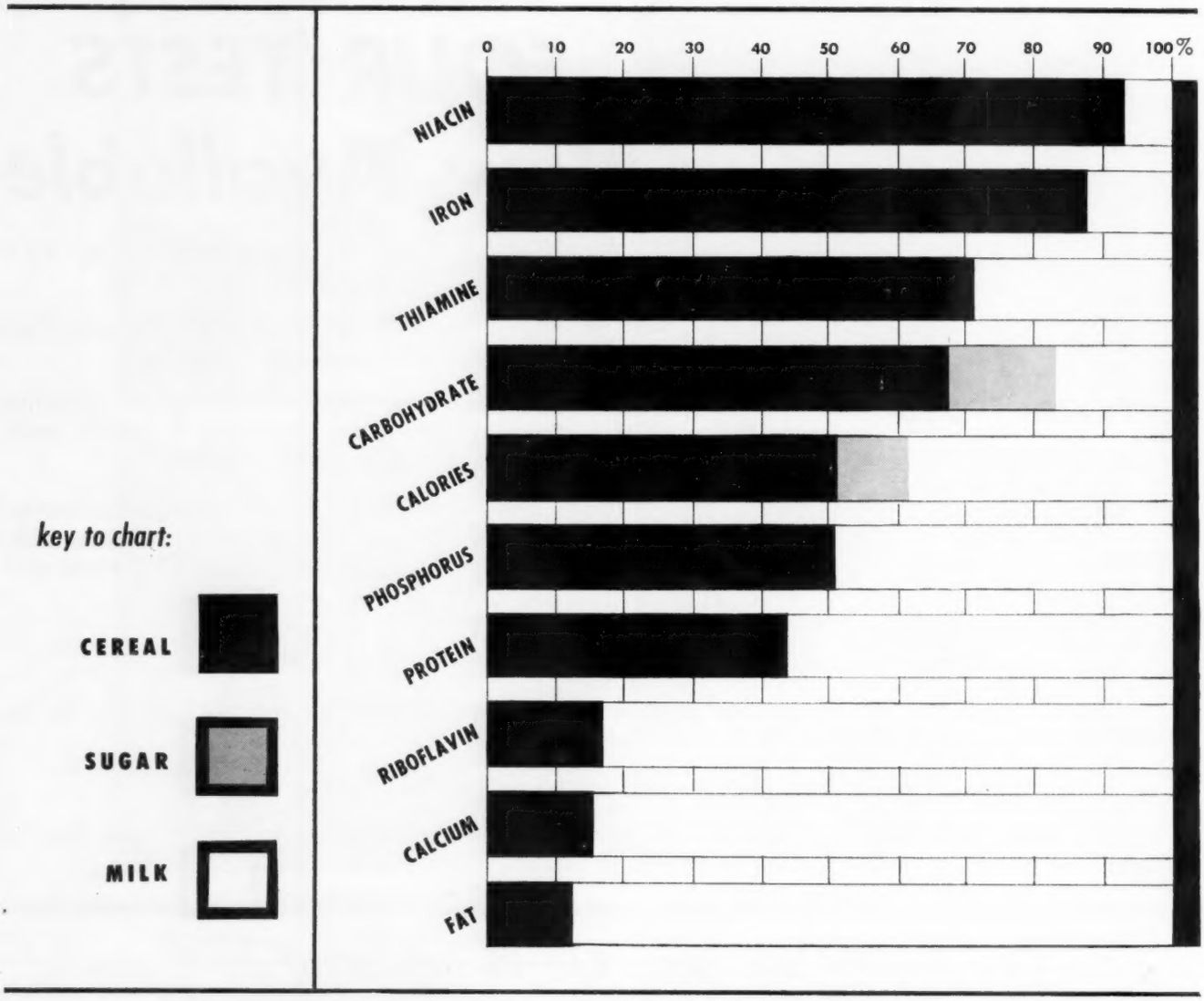

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NSTA CALENDAR

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST*'s calendar editor as early as possible.

March 24-29, 1961: NSTA Ninth Annual National Convention, Hotel Sherman, Chicago, Illinois

April 2-7, 1961: Annual Conference, Association for Childhood Education International, Sheraton-Fontanelle Hotel, Omaha, Nebraska

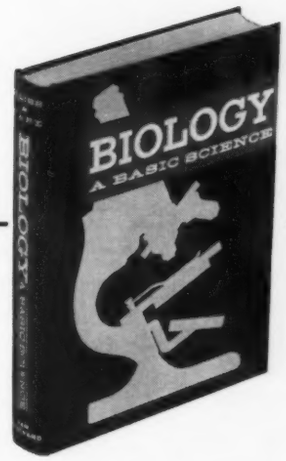
July 7-9, 1961: Annual Business Meeting of Board of Directors, NEA Building, Washington, D. C.

Youth Science Study Tour

Next summer, NSTA will sponsor five students to participate in the Third International Youth Science Fortnight to be held at the University of London, July 21-August 4, 1961. Following this event, the students will devote about two weeks to a science study tour of the Netherlands, West Germany, Switzerland, and France. Under the patronage of HRH The Duke of Edinburgh, the event is organized and conducted by the Worldfriends organization in conjunction with the British Association for the Advancement of Science.

Richard W. Westwood

Many NSTA members, along with thousands upon thousands of conservation and nature educators, will be saddened to learn of the death by cancer on February 13 of Richard W. Westwood, sixty-four, editor of *Nature Magazine*, past president of the American Nature Association, and an active participant in the annual December joint meetings of the science teaching societies of the American Association for the Advancement of Science. He had retired in January 1960 after thirty-seven years with the ANA and the magazine in Washington, D. C. A native of Newtonville, Massachusetts, he attended the Huntington School in Boston and the Columbia University School of Journalism; served with the American Field Service of the French Army in World War I; later joined the U. S. Army at Verdun, was wounded, and received the French Croix de Guerre. The family has requested that expressions of sympathy be in the form of contributions to the American Cancer Society.



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BOOK Reviews

Policies for Science Education. Edited by Frederick L. Fitzpatrick. 220p. $3.95. Bureau of Publications, Teachers College, Columbia University, New York 27, N. Y. 1960.

This current publication, addressed primarily to school administrators, supervisors, and the general public, presents the thinking of thirteen leading science educators relative to the education of science teachers in this country. The report states current problems and trends clearly, analyzes the varied aspects of the situation carefully, and makes numerous worthwhile recommendations—all with an authority that is enhanced through preparation by the Bureau of Publications, Teachers College, Columbia University, and issuance as a monograph of the "Science Manpower Project." Consequently, the book is likely to be quoted widely and to have some salutary effect on the future course of science education.

In some ways the monograph is reminiscent of the platform of a political party. It takes a stand on most, if not all, of the major problems facing science education today and presents them in carefully worded statements with which it is difficult to take issue. One wonders, however, in what respects the report might have differed if it had been written by an equally distinguished panel that did not consist predominantly of staff members and former students of Teachers College.

Truisms and generalities abound in the report; specific references are seldom cited. There are many statements like:

> Children need an opportunity for planned exploration of areas of science with which they may be unfamiliar.
>
> Teaching science to children is an attempt to help them investigate and understand.
>
> An important end of science teaching . . . is accurate concept formation.

Some statements, initially made with conviction, seem to warrant less certainty upon careful reflection. For example:

> Pressures brought by parents seeking special concessions and treatment for their children . . . [have a general effect which] . . . is to undermine sound policy by waiving reasonable educational requirements and establishing "easier" programs. [This seems to indicate that parents are generally anxious for their children to have sound schooling and that they are sometimes ahead of school administrators in this regard.]
>
> We need to be aware that teachers dealing with different kinds of students in a variety of communities are faced with widely differing instructional problems. [We question whether photosynthesis in Florida sugar cane is basically different from that in potato plants in Maine, or whether the city boy in Brooklyn needs to know anything different about the behavior of electrons than does the farm boy in Minnesota.]
>
> We should increase the science requirement for prospective elementary school teachers to at least twenty-four semester hours. [Any faculty member of a college whose chief function is the education of prospective elementary school teachers, who are now required to take twelve hours of science, can imagine representatives of social studies, English, mathematics, art, music, and other departments demanding proportionate increases in their curricula.]
>
> . . . the instruction that [the high school science teacher] has received in subject-matter courses has been designed to serve quite a different purpose from that of educating secondary school teachers. [One wonders if this is actually true, in general, of well-designed and well-taught courses. How, for example, should a second-year college physics course for prospective secondary school science teachers be different from one taught to a general group of science majors? How can an introductory geology course that is applicable for liberal arts students be less so for prospective teachers of general science?]

A few of the ideas presented in the report are novel and worthy of further exploration. Particularly interesting are such statements as:

> . . . it may be anticipated that the current need for superior secondary school teachers of all subjects will lead to the development of a new type of teacher-training institution [which] would be neither the teachers' college nor the liberal arts college of the moment, but one in which the curriculum would be designed to educate pro-

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spective secondary school teachers so that they have adequate knowledge of the subject they are going to teach, and are well-grounded in the psychology, guidance, administration, and methodology that make for professional competence.

When new teachers with the required attributes are in short supply, certification laws will be meaningless unless they are policed and some significant penalty is incorporated. . . .

One suggestion is that national levels of competence [for teachers] higher than any of those set by individual states might be established. Examinations would be held for those who received national certification; the Federal government might supply an additional stipend of from $1000 to $2000 per year.

Most of the recommendations made in the monograph are hardly new to mature science teachers, but some may have been missed heretofore by many administrators. For example:

It is recommended that [high school courses in general biology, physics, and chemistry] be assigned six periods of instruction per week [with] at least one double laboratory period per week. . . .

The laboratory time of science teachers must be adequately recognized in assigning teaching loads.

School administrators should encourage teachers to participate in local workshop experiences, to hold membership in professional societies, to attend professional meetings, and even to carry on research activities upon occasion.

This book should prove to be a timely and valuable aid to education. It is worthy of careful study by school administrators, and more particularly, by parent-teacher associations, chambers of commerce, civic clubs, and other lay groups. If every science teacher were to buy a copy, donate it to the local public library, direct it to the attention of his community, and urge civic groups to undertake the perusal and deliberation of its recommendations, he would help to insure the educational welfare of our country and its citizens.

In the final analysis, the reviewer feels that an index, which is lacking in the monograph, would have been helpful. Since teacher education is the key to the entire situation, it might have been better, therefore, to have treated this topic earlier in the report and more extensively.

VICTOR E. SCHMIDT
State University Teachers College
Brockport, New York

The World Book Encyclopedia. 20 volumes including a Reading and Study Guide. 11,720p. Price (depending upon binding) $139 to $179, discounts to schools and libraries. Field Enterprises Educational Corporation, Merchandise Mart Plaza, Chicago 54, Ill. 1960.

The World Book Encyclopedia editors state that the 1960 revision is enhanced by the addition of 10,000 new and revised articles, a new program of 1775 maps, more than 5000 new or completely revised biographies, 4000 completely illustrated articles, and new "transvision" illustrations. Color is used to good advantage in the charts, maps, and illustrations throughout the volumes.

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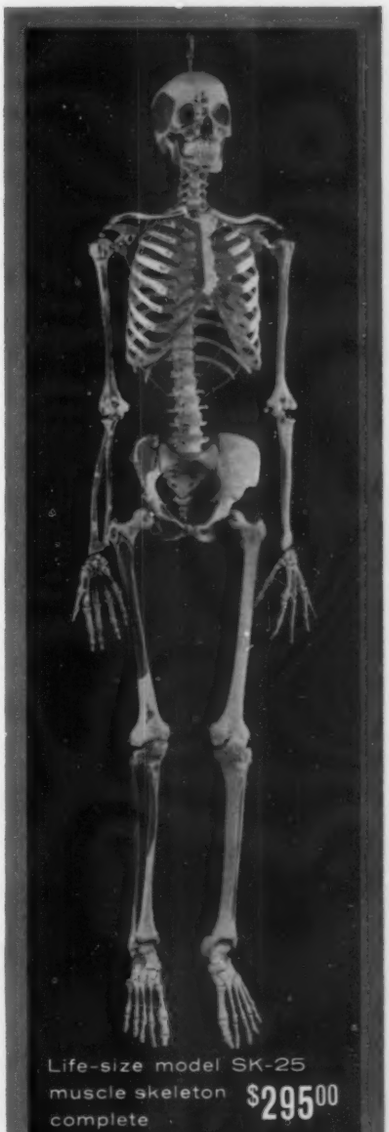

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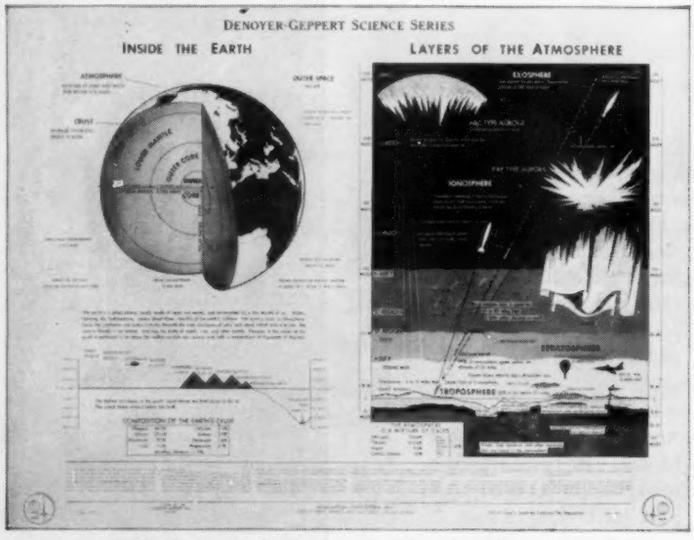

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Multi-purpose use of the charts is possible. They may be used individually or in groups. The content and manner of presentation is such that they can be adapted to many levels of age and learning readiness. Their visual format makes it possible to use many of them even in the primary grades without the need for children to read the text. The creative teacher will find they open the doors to many experiences beyond the scope of a single type of resource.

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1. Life on Earth
2. Plants
3. Plant Classification
4. Animals
5. Animal Classification
6. Carbon-Oxygen-Nitrogen Cycles
7. Human Nervous System
8. Human Muscular and Skeletal Systems
9. Human Circulatory and Digestive Systems
10. Human Respiratory, Lymphatic and Endocrine Systems
11. Food
12. Health and Safety

DGSII The Science of the Earth

1. Picture History of the Earth
2. The Earth as a Sphere
3. Relationships of Earth and Sun
4. Maps
5. Time
6. Inside the Earth and Layers of the Atmosphere
7. Wind Systems of the Earth
8. Changing Surface of the Earth
9. Rocks and Minerals
10. Rocks and Soils
11. Water on the Earth
12. Conservation

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tributors insure the authority of the encyclopedia. Reading and language improvement are developed by the progression of word use from the simple to the complex and through specific articles slanted to either a high or low reading level, depending on the subject matter. Thus, *The World Book* provides a wealth of readable material for elementary and junior high school students as well as students at the senior high school level.

The reviewing committee recommends *The World Book* to science teachers as a valuable instructional aid. Although this encyclopedia is not a technical reference work, its contents are stimulating and make an excellent basis upon which to build more knowledge from specific textbooks and other related materials.

LEHAN EDWARDS, Winthrop, Maine
BLAIR CARBAUGH, Converse, Indiana
ALFREDO CRUZ, Arecibo, Puerto Rico
EUGENE WILLIAMS, Warren, Pennsylvania
JOSHUA FREEBERG, Philipsburg, Pennsylvania
(*National Science Foundation Institute Students*)
Pennsylvania State University
University Park, Pennsylvania

Soviet Education Programs. William K. Medlin, Clarence B. Lindquist, and Marshall L. Schmitt. 232p. $1.25. U. S. Office of Education, Department of Health, Education, and Welfare, Bulletin 1960, No. 17. Order from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 1960.

This is the third report since 1957 published by the U. S. Office of Education (Washington, D. C.) on the subject of the Soviet school system. It represents results of a study completed by a select group of educators who visited the USSR. The authors, members of the staff of the Office of Education, are: William K. Medlin, Specialist in Comparative Education for Eastern Europe, Division of International Education; Clarence B. Lindquist, Chief of Natural Sciences and Mathematics, Division of Higher Education; and Marshall L. Schmitt, Specialist for Industrial Arts, Division of State and Local School Systems.

Subtitled "Foundations, Curriculums, and Teacher Preparations," the book is divided into five chapters entitled: Foundation of Soviet Educational Practices, Science and Mathematics in the General Schools, Polytechnic Education in the General Schools, Teacher Education, and Conclusions. The report covers the recent reorganization and polytechnization of the Soviet educational system. It also gives a clear picture of the present status of science teaching in the Soviet Union, the changes that will take place as a result of the reorganization scheduled for completion in 1965, and the preparation of teachers. The polytechnization of schools is probably the most important feature of the present reorganization.

The work is based not only on the personal impressions of the visiting team, but also on a thorough study of Soviet syllabi, textbooks, and other documents. Important factual material that will be helpful to anyone who is interested in Soviet education is included. Covered in detail are the methods of teaching biology, chemistry, mathematics, physics, and astronomy in Soviet schools. Eight pages are devoted to pedagogical research in these subjects and a description of the distribution of hours by grades and units. Sample examinations for some of these courses are shown. According to the authors, the most important difference between the American and Soviet school system is that in Russia "Subjects are taught in parallel sequences over a period of years, rather than in concentrations at different levels of the educational ladder." Nine appendixes furnish valuable information on Soviet education.

Chapter III, Polytechnic Education in the General Schools, discusses: (1) the philosophy and purpose of polytechnic education, (2) polytechnic courses, (3) the new curriculum reforms, (4) organization and operation of school workshops and production training, (5) organization methods of teaching polytechnic subjects, and (6) research.

Although a good bibliography is provided, this reviewer would suggest the addition of an important collection of articles and documents about the recent reorganization. This collection is entitled *Novaya Systema Narodnogo Obrazovaniya SSSR. Sbornik dokumentov i statei* (The New System of Public Education in the USSR Collection of Documents and Articles). Edited by N. K. Goncharov and F. F. Korolev. Izdatel' stvo Akademii Pedagogicheskikh Nauk. Russian

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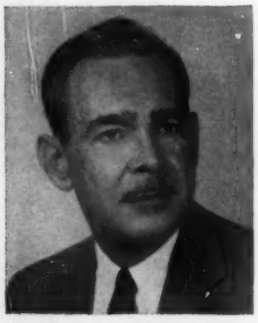
PETER GRAY. Head of the Biological Sciences Department, University of Pittsburgh, Pittsburgh, Pennsylvania. Chairman of "Here's How I Do It" College Session, Saturday afternoon. Topic: "Newer Concepts in Science."

OREON KEESLAR. Coordinator of Secondary Curriculum, Santa Clara County Schools, San Jose, California. Chairman of the General Planning Committee, 1961 NSTA Convention. Participant in "Here's How I Do It" Organizations Session, Saturday afternoon. Subject: "The Story of a Joint Council on Science and Mathematics Education."

H. SEYMOUR FOWLER. Associate Professor of Science Education, Pennsylvania State University, University Park, Pennsylvania. Chairman of NSTA's Teaching Materials Review Committee, Dr. Fowler will preside at film showings Saturday morning and afternoon, Sunday morning, Monday morning, and Tuesday afternoon.



HOWARD F. FONCANNON. Special Assistant for Scientific Personnel and Education, National Science Foundation, Washington, D. C. Parallel Session speaker, Sunday morning. Topic: "Teacher Projects to Aid Professional Growth."

CLYDE E. PARRISH. Cubberley High School, Palo Alto, California. Member of the Curriculum Consultant Service, Saturday morning. Chairman of the Special Feature presentation on Sunday afternoon—The Northern California Committee on Problem Solving in Science (NCCOPSIS).

FRED R. SCHLESSINGER. Associate Professor of Education, The Ohio State University, Columbus, Ohio. Participant in Supervisors' Panels, Friday afternoon. Topic: "Facilities, Supplies, and Equipment." Chairman of Parallel Session on Monday afternoon: "Improving Physical Facilities for Excellence in Science Instruction."

ELEANOR E. AHLERS. Executive Secretary, American Association of School Librarians, Chicago, Illinois. Chairman of Parallel Session on Monday afternoon: "The Role of Library Materials in the Teaching of Science."

LOUISE A. NEAL. Associate Professor of Elementary Science, Colorado State College, Greeley, Colorado. Member of the Curriculum Consultant Service, Sunday morning. Speaker at Elementary School Science Discussion Group, Tuesday morning.

N FEATURES

rch 24-29, 1961, Chicago, Illinois

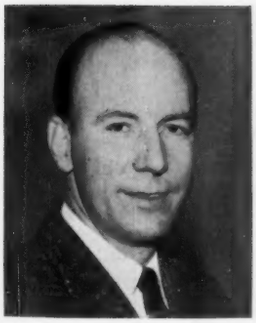
FRED L. FITZPATRICK. Director of the Science Manpower Project, Teachers College, Columbia University, New York City. Member of the Curriculum Consultant Service, Saturday afternoon.

HUBERT N. ALYEA. Princeton University, Princeton, New Jersey. Participant in the "Here's How I Do It" College Session, Sunday morning. Topic: "Projection Techniques: Part I—Physical Sciences."

SISTER M. HERMIAS MENNEMEYER, S.S.N.D. St. Francis Borgia High School, Washington, Missouri. Participant in the "Here's How I Do It" Sessions on Saturday afternoon and Sunday morning. Subject: "Adventures in Radioactivity for High School Students."

JOHN N. SHIVE. Director of Education and Training, Bell Telephone Laboratories, Murray Hill, New Jersey. Presentation of a Special Demonstration on Sunday afternoon: "Similarities in Wave Behavior."

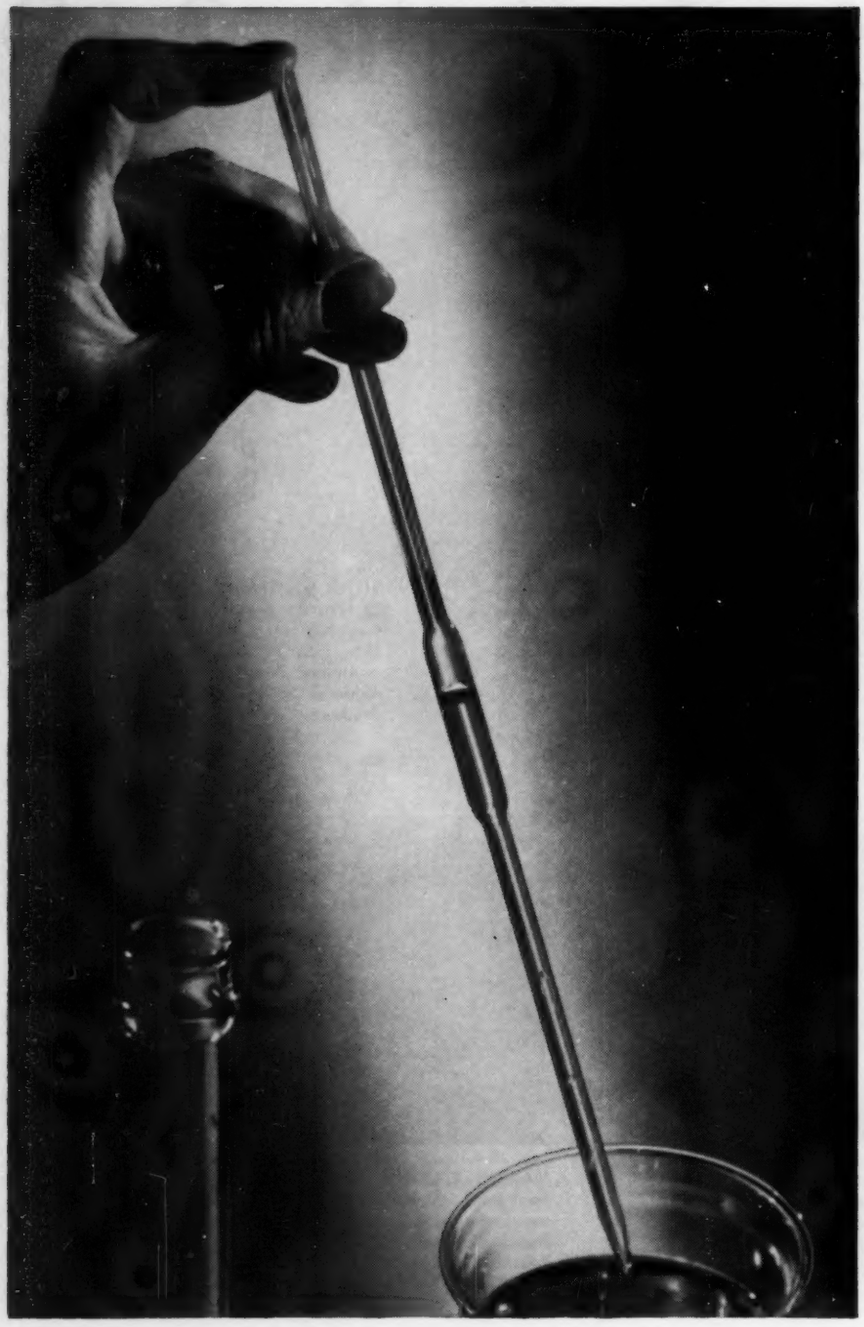
MARION E. JONES. Kimberly-Clark Corporation, Neenah, Wisconsin. Panel speaker in Monday afternoon Parallel Sessions. Subject: "Building Excellence in Teaching with the Help of Sponsored Materials."

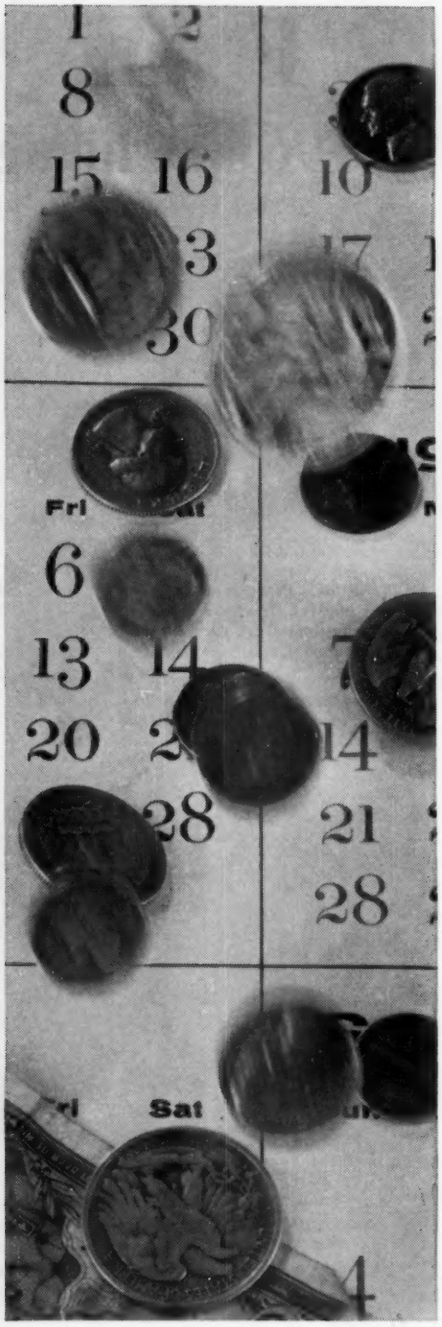


ROBERT L. HELLER. Head of the Department of Geology, University of Minnesota, Duluth, Minnesota. Speaker in the Concurrent Sessions on Major Science Curriculum Studies, Tuesday evening. Topic: "Duluth Conference Geology Study Group."

J. ARTHUR CAMPBELL. Chairman of the Department of Chemistry, Harvey Mudd College, Claremont, California. Speaker in the Concurrent Sessions on Major Science Curriculum Studies, Tuesday evening. Topic: "Chemical Education Materials Study (ACS)."

FRANCIS L. FRIEDMAN. Professor of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts. Speaker in the Concurrent Sessions on Major Science Curriculum Studies, Tuesday evening. Topic: "Physical Science Study Committee (NSF and Others)."





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Soviet Federated Socialist Republic. Moscow. The nine appendixes contained in the book will prove valuable to readers who are interested in Soviet education.

The reviewer highly recommends this book to science teachers and other educators. The recommendation would be unqualified except for two features—the authors do not emphasize the shortcomings of the Soviet educational system, much of which has been covered in both Soviet and American newspapers. Readers should know more about the sweeping reorganization, developing since the early thirties, which will entirely change the Soviet school system.

GEORGE SIEMIENCOW
Lafayette College
Easton, Pennsylvania

Tactics of Scientific Research. Murray Sidman. 428p. $7.50. Basic Books, Inc., 59 Fourth Ave., New York 3, N. Y. 1960.

This work, although directed to the student of experimental psychology, involves a basic and highly provocative treatment of scientific method. The examples are specialized, having been drawn largely from the author's extensive laboratory experience. Fortunately, however, Dr. Sidman writes well, and for this reason the examples will be understandable to readers from other fields. The methods which he discusses are the product of recent developments in both the philosophy and technology of the experimental analysis of behavior. The examples cited deal, for the most part, with experiments in which animals have been conditioned to press a lever in an environment which is highly controlled. The key to these methods is the achievement of precise laboratory control over the behavior of the individual organism, and the book cites a wide variety of laboratory techniques, each of which contributes to this control. There are several points at which one may take issue with Dr. Sidman. For example, his discussion of steady-state behavior features the inadequacies of experimental (and statistical) designs which fail to evaluate interaction effects. This discussion does not, however, give recognition to the numerous designs which will permit the detection of interaction effects. Dr. Sidman's position is strongly stated and perhaps for this reason, as much as any, the book will receive opposition from some readers. Nevertheless, there is much to be learned from this work, for it represents a vigorous presentation of an orientation to behavioral research that is new and that may well prove to constitute a major advance in the field.

HOWARD S. HOFFMAN
Pennsylvania State University
University Park, Pennsylvania.

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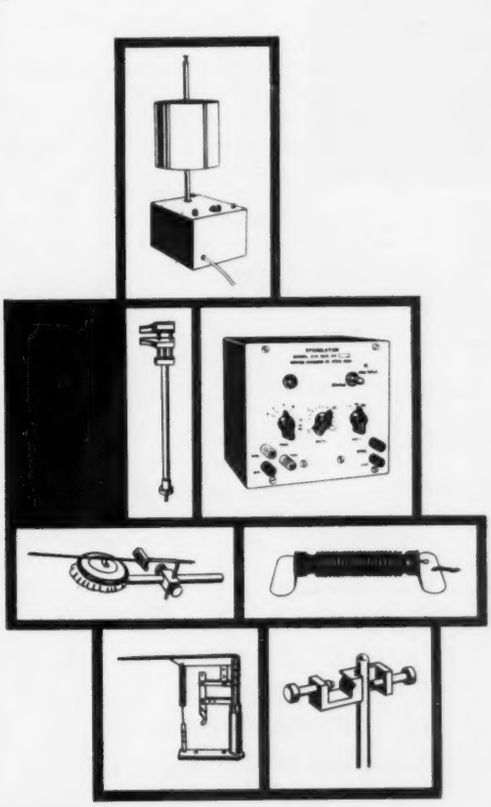

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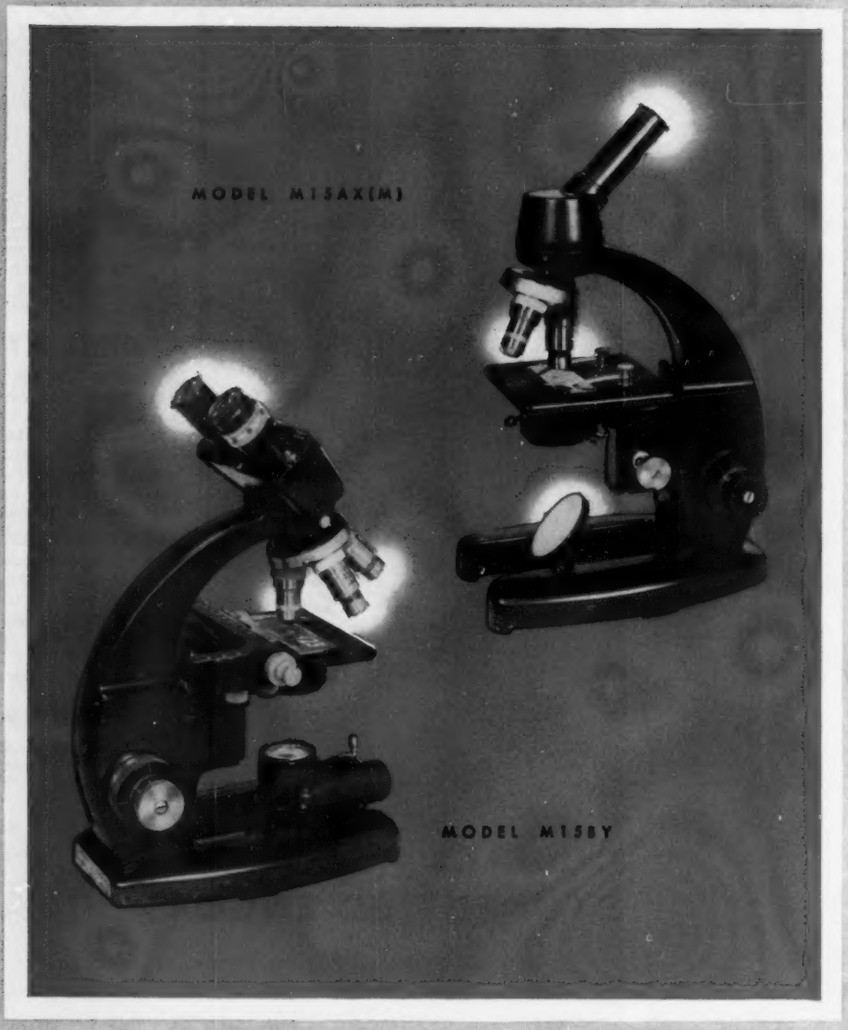

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Prepared by NSTA Teaching Materials Review Committee

Chairman: Dr. H. Seymour Fowler

The Pennsylvania State University, University Park, Pennsylvania

BOOK BRIEFS

Plants Today and Tomorrow. Margaret O. Hyde. 158p. $3. Whittlesey House, McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N. Y. 1960.

A fascinating and up-to-date account of plant research for advanced intermediate-grade and junior and senior high school students. Interestingly written and illustrated with good suggestions for plant experiments. The work of many researchers is described, and Earth, ocean, and space gardens are explored. Plant breeding and research, the use of plants in medicine, plant disease, and other topics are presented in a way that excites the imagination.

Meadows in the Sea. Alida Malkus. 72p. $2.75. World Publishing Company, 2331 West 110th St., Cleveland 2, Ohio. 1960.

Introduces young readers (ages 10-14) to the sea world of plankton, protozoans, crustaceans, mollusks, and chordates. Interrelationships between these life forms and the physical factor of environment limiting them are described, *i.e.*, the chain of life at sea. Numerous drawings and diagrams clarify the text.

Man and Space. Eline E. Davis. 96p. $2.75. Dodd; Mead and Company, 432 Fourth Ave., New York 16, N. Y. 1960.

An up-to-date account of space and space exploration. Content of the book deals with accumulated knowledge about other planets, the earth and its atmosphere, and the space research programs such as Project Mercury, Project Tiros, and Project Defender. Implications of space research for military and civilian purposes are discussed. Recommended as supplementary reading for junior high school students.

The Arithmetic of Computers. Second Revision. Norman Crowder. 472p. $3.95. Doubleday and Company, Inc., Garden City, N. Y. 1960.

An example of the Crowder method of "programming" learning materials in textbook form. This revision is the result of experience with the first edition which was written as an experimental study for sixth graders. The self-teaching "Tutortext" attempts to train the reader to compute in the binary and octal number systems (bases of two or eight). Many elementary school teachers who have not studied modern mathematics recently may find this "Tutortext" an easy method for mastering the arithmetic of the electronic computer.

Of Mice, Men and Molecules. John H. Heller. 176p. $3.95. Charles Scribner's Sons, 597 Fifth Ave., New York 17, N. Y. 1960.

In an exciting and challenging manner, the author explores the frontiers of the unknown. He discusses not only the drama of current research but predicts the research of the immediate and distant future. Covered in the book (which is one of basic research) are such diverse topics as mood, madness, weather, heart disease, chemical warfare, and undersea research.

When the Stars Come Out. Robert H. Baker. 190p. $1.25. The Viking Press, Inc., 625 Madison Ave., New York 22, N. Y. 1960 Revision.

Presents an enthusiastic explanation of the heavens with thirty pages of photographs, maps, and charts. Recommended for young

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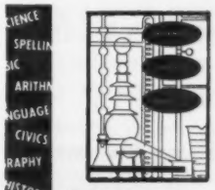

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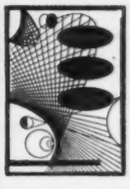

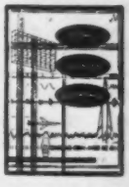

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people and for older readers who prefer a book on astronomy relatively free of technical terminology. Many revisions have been made.

Three Essays on Population. Thomas Malthus, Julian Huxley, and Frederick Osborn. 138p. 50¢. The New American Library of World Literature, Inc., P. O. Box 2310, Grand Central Station, New York 17, N. Y. 1960.

A book of three timely essays that analyzes a critical world problem—the "Population Explosion." Malthus, Huxley, and Osborn point out the need for some form of universal birth control policy, but add that religious, economic, and social problems must be solved before this policy can be put into effect. Recommended reading for high school students and for the general public.

Wonders of the Anthill. Sigmund A. Lavine. 64p. $2.95. Dodd, Mead and Company, New York 16, N. Y. 1960.

An interesting and useful source of authoritative information on ants in general and on the various species. Much of the content is presented too academically and at too high a level for reading by any but the most able students in the upper elementary or junior high school grades. Illustrated in two colors.

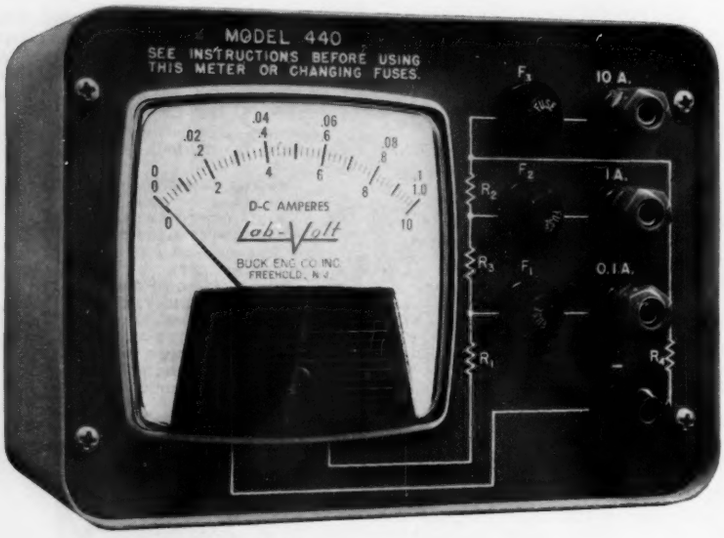
Project Ideas for Young Scientists. Edited by John K. Taylor in collaboration with Phoebe Knipling and Falconer Smith. 142p. $1.25. Joint Board on Science Education, 1530 P St., N. W., Washington 5, D. C. 1960.

An annotated compilation of possible student projects in a wide variety of scientific disciplines. The text begins with a brief generalization and explanation concerning student work and the proper method of approach followed by specific examples of student projects for investigation. This book represents one of the most practical pieces of source material for science teachers recently produced. Immediately available, it will assist teachers at any grade level in the junior and senior high schools.

Man's Place in Nature. Thomas H. Huxley. 184p. $1.75. University of Michigan Press, Ann Arbor, Mich. 1959.

This book consists of three essays: "On the Natural History of the Man-Like Apes," "On the Relations of Man to the Lower Animals," and "On Some Fossil Remains of Man."

In the first essay Huxley gives a clear account of the structure of the man-like apes, preceded by a fascinating history of our knowledge of these creatures. In the second, he attempts to show that man has developed in a manner similar to that of the animals immediately below him. The third essay explains man's lowly origin. Contrary to what has been reported about Huxley's writings, nowhere does he indicate



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that man has descended from a chimpanzee or gorilla; on the contrary, he emphasizes the great difference between man and the apes. *Man's Place in Nature* is one of the great classics of science which all biology teachers and students should read.

The Universe at Large. Hermann Bondi. 154p. 95¢. Doubleday Anchor Books. Order from Wesleyan University Press, Inc., Columbus 16, Ohio. 1960.

How large is the universe? How old are the galaxies and stars? How rapidly are distant galaxies receding from the earth? Why is it dark at night? What takes place inside stars and between stars? How did the universe begin and where is it going? What are the "steady-state" and "exploding" theories of the universe? These questions are answered in this volume of the Science Study Series prepared under the direction of the Physical Science Study Committee of Educational Services Incorporated. Suitable for advanced high school students.

Life of Pasteur. Rene Vallery-Radot. 464p. $2. Dover Publications, Inc., 180 Varick St., New York 14, N. Y. 1960.

An interesting and complete work, translated from the French, on the life of Louis Pasteur. The book covers many accounts of Pasteur's scientific studies, the reception of his discoveries, and the influence of other great men on his life. Included also are descriptions of his experiments with crystals, vinegar, silkworms, and such diseases as rabies. Much of the work is devoted to first-hand reports by Pasteur on the defense of his doctrines. The author also includes direct quotations from a lecture on "spontaneous generation," letters to Pasteur's father, and other writings. The book will be recognized as a full study of the life and work of Louis Pasteur and is highly recommended for reading by high school students.

Educators Guide to Free Filmstrips. Compiled and edited by M. F. Horkheimer and J. W. Diffor. 164p. $6. Educators Progress Service, Randolph, Wis. 1960.

The 1960 edition of this teaching favorite lists 624 titles of filmstrips and slides and contains 69 new listings over the eleventh edition. The guide would be appropriate for science and health classes.

Educators Guide to Free Science Materials. Compiled and edited by M. H. Saterstrom. 298p. $6.25. Educators Progress Service, Randolph, Wis. 1960.

This is the first edition of a new guide similar to others produced by this publisher covering various free materials. Contains lists of films, filmstrips, and other curriculum aids. All materials are easily located in a Title Index, Subject Index, or Source and Availability Index. Ten resource units are also included. Would be a useful aid for high school teachers of science.

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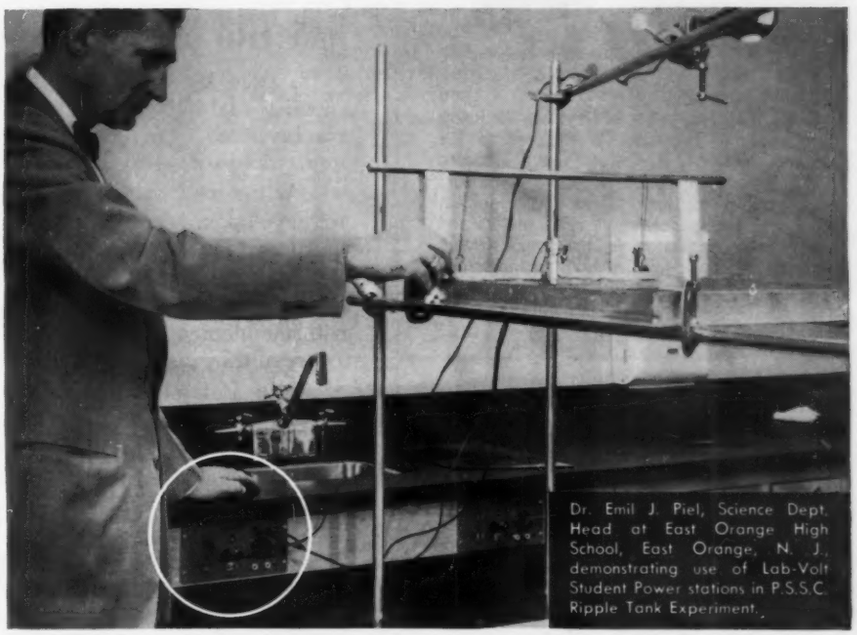
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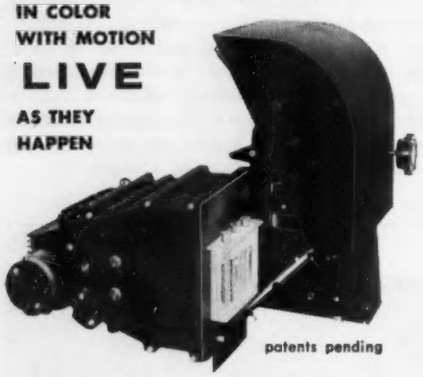

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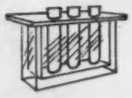

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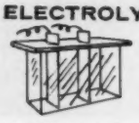

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"Chemiluminescence-Variations." *Journal of Chemical Education,* 37:A739. November 1960. This article describes an inexpensive method for demonstrating the phenomenon of chemiluminescence in virtually any high school science laboratory. The demonstration illustrates a current facet of basic scientific research and is applicable to science teachers in all fields.

"Contribution of Thomas A. Edison to Thermionics." By J. B. Johnson. *American Journal of Physics,* 28:763. December 1960. Readers interested in the history and development of electronics will enjoy this article which describes the work of Edison and other investigators. Includes reproductions of some of Edison's original drawings and notes. The article points out how Edison, and others, incorrectly assumed that the current flow in a vacuum tube between the plate and filament was a movement of ions rather than of electrons.

"Competence in Science Teaching." By Frank Olsen. *Panorama,* 2:16. Autumn 1960. The preprofessional competence and needed in-service activities of the science teacher are discussed. Although the author is an Australian, his recommendations are similar to those being considered by United States authorities on science teacher training.

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Exploring Space. Topics covered are the necessity of oxygen for combustion in an airplane engine, why there is a ceiling for the height an airplane can fly, the difference between rockets and an airplane engine, Newton's third law of motion, "back pressure," rocket fuel and firings, and photography from rockets. Many excellent models are used to help clarify principles. Demonstrations are presented to show the energy releasing properties of rocket fuels. For grades 7-12. 25 min. Color $175, B&W $100. 1960. Contemporary Films, 276 West 25th St., New York 1, N. Y.

Frames of Reference. This extremely interesting film opens immediately with a dramatic scene illustrating the illusion of a stationary frame of reference. Two men are shown—one is upright and the other is upside down. The upright man, however, proves to be upside down in reference to the earth as a frame. Other demonstrations illustrate illusions of motion. An air puck is shown as an example of motion in this context. It is explained that all frames of reference are equal if they are moving at the same velocity. As one of the Physical Science Study Committee film series, it is

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recommended for advanced physics students. 25 min. B&W $150. 1960. Modern Learning Aids, 3 East 54th St., New York 22, N. Y.

The Story of Palomar. This is an outstanding documentary film which demonstrates the complete history of the 200-inch Hale Reflecting Telescope. Shows the preparation of the site, the lens, and the use of the telescope. Pictures the great scientists and technicians associated with the project. Some important light-ray diagrams are shown. The film would be useful in general science, earth science, and physics. 39 min. Color $350, B & W $190. 1960. Encyclopaedia Britannica Films, Inc., 1150 Wilmette Ave., Wilmette, Ill.

Forces. In a film narrated by Dr. Jerrold R. Zacharias of the Massachusetts Institute of Technology, the interactions between small bodies are demonstrated through the use of the classic Cavendish experiment. These are compared to electrical and nuclear forces between bodies. This film, part of the Physical Science Study Committee film series, foreshadows others on the subject. Recommended for general high school physics students. 23 min. Color $120. 1960. Modern Learning Aids, 3 East 54th St., New York 22, N. Y.

Atomic Achievements. An interesting film which tells the story of the development of nuclear power stations in Britain. Shown

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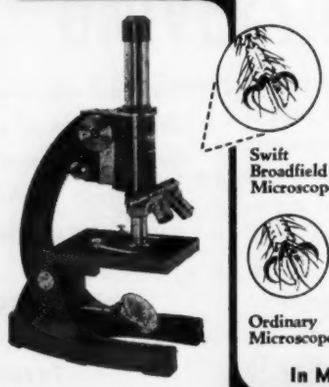

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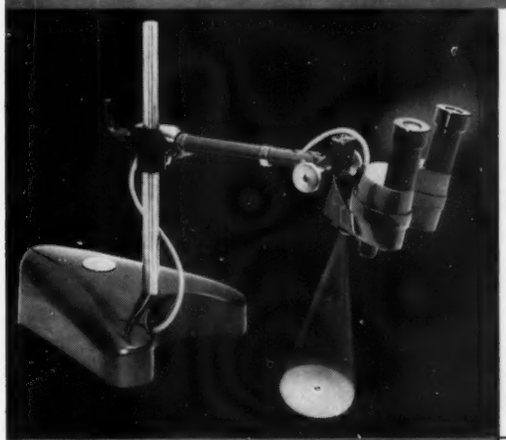

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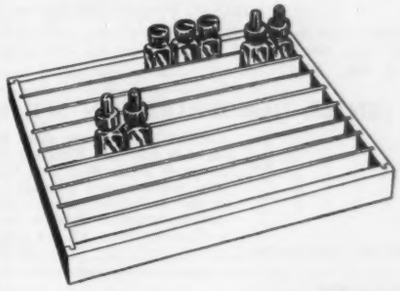

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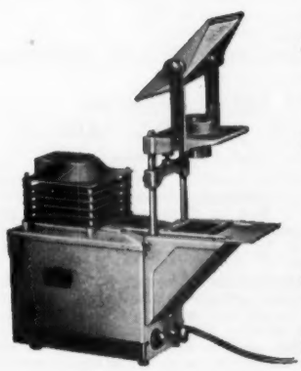

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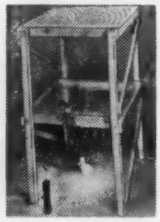

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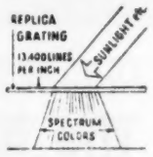

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Trees—Our Plant Giants. Film describes the characteristics of trees and their contributions to man. Many interesting features are portrayed including the difference between coniferous and deciduous trees, determination of the age of trees, and man's use of lumber in railroad ties, paper, turpentine, and other products. The relation of trees to soil conservation is explained. The film is well done and is therefore recommended for science classes, grades 3-7. 14 min. Color $140, B&W $75. 1960. Academy Films, 800 North Seward St., Hollywood 38, Calif.

Introduction to Dissection. A clear and comprehensive presentation of dissection showing methods as well as proper care and use of instruments. The film accomplishes in eleven minutes what would consume several periods for the classroom teacher. Recommended for junior and senior high school general science and biology classes. 11 min. Color $110. 1960. International

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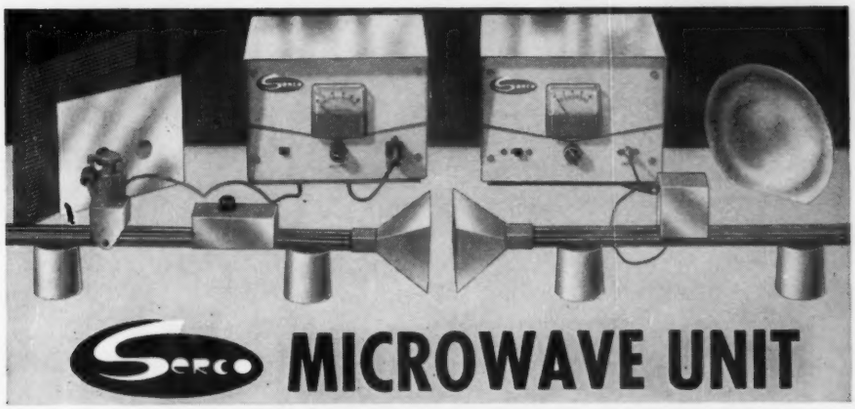

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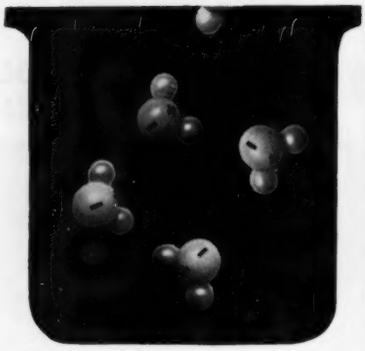

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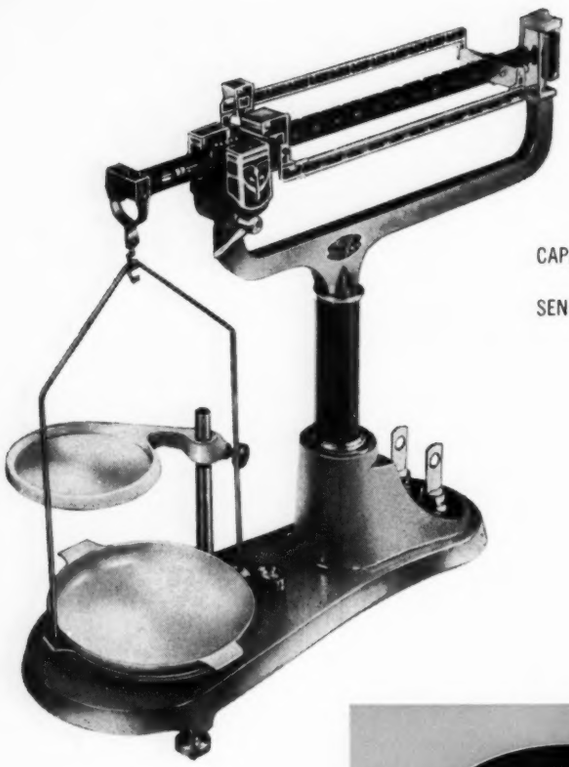

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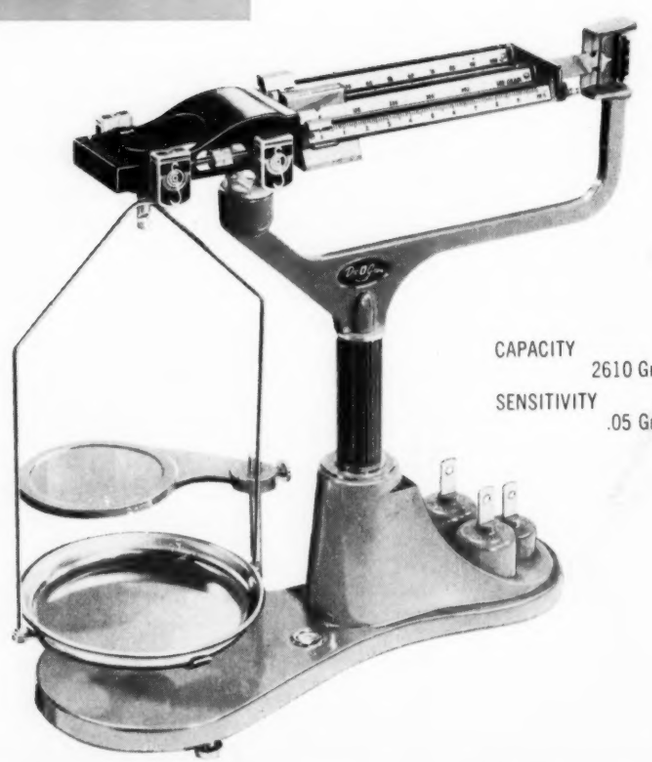

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